MACHINERY.

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AN INTERESTING LETTER FROM AN OLD ENGINEER.

GEORGE ESCOL SELLERS.

WHILE this article is somewhat of a departure from our regular practice, we feel that it will be read with interest by many who know the writer personally, or who are acquainted with other members of his celebrated family. Mr. Sellers was born in Philadelphia, November 26, 1808, and as he has been engaged in mechanical pursuits from his youth, his active life has covered a period of great industrial progress in this country. He has followed a variety of mechanical pursuits, such as the manufacture of wire work, locomotive building, paper making, the manufacture of lead pipe, steam hammers, etc. Of late years he has devoted much time to anthropological research, as the letter will show, and this is not without interest to the mechanic.

In a future issue we hope to present a full account of his long mechanical career. ED.

"CRESTVIEW,"
RIDGEDALE, TENN.,
Sept. 13, 1895.

Editor Machinery:

DEAR SIR: Yours of the 20th ult., with the August number of MACHINERY, came duly to hand and should have been immediately replied to, but the photograph you ask for was not at hand, and I felt too unwell to look it up; it was taken about the first of the year. After finding it, one interruption after another prevented me getting into my den. The preparation for the dedication of the National Military Park, though I have nothing to do with it, owing to my location here brought a continued succession of inquiring sightseers.

Geo: Escol Sellers

Some time ago, in answer to letters and verbal inquiries, I wrote for the *American Machinist* what may be considered as my valedictory. My failing eyesight and other infirmities of age, admonishes me that the time has come to halt.

In writing the paper, I devoted considerable space to the state of mechanical arts of the prehistoric people of the stone ages, which has always been a hobby of mine, divesting it of all preconceived theories and studying it from a purely mechanical standpoint—not so much from fine specimens of flaked and polished stone work as by delving into the wastage of the old outdoor work shops—the masses of chips, flakes, rejected, partly finished, broken, imperfect, the cores from which the flakes were made, the remnants of bone and horn implements, the coarse-grained rub or grind-stones, all objects for study and thought, and practice for the hands in the reproduction of the works of art, erroneously treated of as lost, but that were once broadcast over the entire inhabited globe, and as much a precise art as the most refined mechanical of the present time.

Then as to the most ancient pottery, the modes pursued in its production, is clearly marked in the leavings of the old outdoor working places there are occasionally encountered, and the theory of modeling bottles on unyielding goods which were burned out in baking. How such an idea could have ever been conceived by a thinking man, advanced and accepted for many generations, is a mystery to me, when the merest novice must know that any clay rendered plastic by water would crack in drying without ample space for shrinkage was given. The theory of moulding open ware in baskets is equally as absurd, when what is taken for impressions of basket structure of reeds, on a close inspection prove to be twisted threads, and by taking clay impressions from the marked pottery, the reverse thus obtained shows the textile fabrics of the prehistoric people in all its integrity, even to knots and splicings; all of which from my mechanical stand-point is so interesting to me that in writing the paper referred to, I let considerable of the subject enter into it. But doubting its fitness for a purely mechanical publication devoted to the present time, instead of sending it directly to the publishers, I sent it through my brother Coleman, with permission to cut and carve; and it appears that on consultation with the publishers this portion was left out, and is now in my brother's possession. It is my intention, if life is spared, to amplify it for publication.

Even in Egypt flaked flints are unearthed in such position as to evidence a rude stone age, preceding that of the Pyramids, and the question is asked, where is the evidence of evolution that lead up to these imperishable monuments. Central America has been pointed to, for there we find similar works of earth rudely faced with stone, carved stone and clay images of decided Egyptian character, with the sunken Atlantis with its fabled advanced civilization as a link connecting the continents. But why look for the records of evolution when man is so destructive an animal in his forward advance, destroying even his foot-prints? I recollect, when a boy, seeing in New York many of the old Dutch houses with their gables to the street; in Philadelphia rows of low story back-headed brick buildings; where are they now? They have given place to structures better suiting the time.

The present condition of both civil and mechanical engineering is on so sure and solid a foundation with an onward course before them, I cannot conceive any advantage to them in anything I could relate of the experience, trials and tribulations passed through in reaching this stage, that I have taken part in, witnessed and watched; but I have not been able to keep up with the progress of the last decade.

The mechanics of the present time might be likened to the advance of a triumphal army, so confident that they destroy the roads and bridges behind them. The crucible and melting fur-

nace for all that is fusible; the pile, heating furnace, forge, hammer and rolls for the malleable, changes the gone-into-disuse into new material.

Many societies and museums are saving sufficient for object lessons; what was done in the railroad exhibit by the Baltimore & Ohio R. R. Co., to record the advance in the locomotive, was in the right direction.

I came into my den to enclose the photograph, to thank you for your invitation to contribute to your journal, and to say it would be impossible for me to do so, and I find that in explanation I have spoiled several pages, which the present condition of my eyes will not permit me to read over.

Yours truly, GEO. ESCOL SELLERS.

* * *

HOW MUCH STOCK WILL YOU CARRY?

W. L. CHENEY.

Assuming that a machine shop is building one a month of a certain machine; how many of the small parts is it best to make in one lot and carry in stock until used?

Let us take the two extremes of making one of these small parts each month as each machine is built, or making 12 of the same parts in one lot, which will evidently last one year under the conditions mentioned above.

I have taken the average of a lot of small parts belonging to a certain machine, to all the information regarding which, that is necessary for an intelligent analysis of the question, I have access, and find that the average time making these pieces is 1½ hours, and the average number of operations (calling lathe work one operation, planer work another operation, etc., not counting polishing, or bench or hand work of any description) is two.

Certainly if a man sets up a machine of any kind, gets tools ready and after the job is done puts tools away, etc., in 15 minutes, he is doing well, and if this is allowed, it follows, there being two machines to set up on each piece, that when one piece is made alone, ½ hour out of the 1½ hours or ⅓ of the whole is used in unproductive labor, when the pieces are made one at a time.

It is now easy to make the comparison, assuming the sum of average wages and shop expenses to be 45 cents an hour on this class of small part work not requiring the highest skill, and the stock to be an average of 5 pounds of cast iron at 2½ cents a pound, as follows:

COST OF ONE PIECE IF MADE ALONE.

1½ hours at 45 cents - - - - - -	.67½
5 pounds cast iron at 2½ - - - - -	.12½
Total cost of one piece - - - - - -	.80

COST OF 12 PIECES MADE AT ONCE.

12½ hours at 45 cents - - - - -	$5.62½
60 pounds cast iron at 2½ - - - - -	1.50
	$7.12½

cost of stock, labor and shop expenses for one year's stock of 12 pieces (or 59⅓ cents each—very nearly—say 59½ cents each for pieces made in lot of 12).

To this must be added the following:

Interest on cost of	11 pieces	for	1 month - - -	.0327
" " " "	10 "	"	2 months - - -	.0595
" " " "	9 "	"	3 " - - -	.0803
" " " "	8 "	"	4 " - - -	.0952
" " " "	7 "	"	5 " - - -	.1041
" " " "	6 "	"	6 " - - -	.1071
" " " "	5 "	"	7 " - - -	.1041
" " " "	4 "	"	8 " - - -	.0952
" " " "	3 "	"	9 " - - -	.0803
" " " "	2 "	"	10 " - - -	.0595
" " " "	1 piece	"	11 " - - -	.0327
				.8507

say 85 cents to be added to the cost of the 12 pieces, making cost of stock, labor, shop expenses and interest on 12 pieces, $7.97½ against $9.60 for 12 pieces when made separately at 80 cents each.

The total saving on these 12 pieces, by making them in one lot is, therefore, $1.62½, or about 13½ cents on each piece, this being a saving of nearly 17 per cent. on each piece.

To recur to the machine mentioned in the beginning: there are 60 small parts in its make up, to which the above figures will fairly apply. This then represents a saving of $8.10 in these small parts alone, in each machine made, and the same estimating will apply in direct proportion to the other larger parts of the machine.

There is another item in this connection that can be figured very closely: taking the same illustration, when the pieces are made one at a time, the ⅓ time of unproductive labor is also ⅓ time of a machine standing idle, whereas the $\frac{1}{25}$ time when made in lots of 12 is but $\frac{1}{25}$ of the time of the machine standing idle. The machine must not only be charged interest on the first cost, *but enough more to replace it* in about ten years, when it will be worn and out of date. That is, not only the interest on the investment must be charged every year, but a certain part of the principal also.

In addition to these things which can be very closely figured, there are other things that cannot be closely figured, and which a man who sees the books only can hardly appreciate, but which I am sure are recognized by every practical shop man. To still use the same illustration, the foreman would need to give a man about six jobs every day instead of about one job in a day and a quarter. It takes just as much of the foreman's time to give out the job of one piece as the job of 12 pieces; it takes as much time to get the pattern and order one casting as 12 castings; it takes almost as much time to keep account of cost of one piece as 12 pieces, the man will not be 12 times as long actually on 12 pieces as on 1 piece, because he will get used to the job before the 12 pieces are done, and will do the 12th piece much quicker than the 1st piece. It therefore takes more of the foreman's time to look out for less work; the yearly production of the shop is much decreased and consequently (less business being done on the same capital) the profits (and the percentage of profit) are reduced.

Every reader of this will easily think of many other disadvantages of working in a hand to mouth manner. I have seen the production of a shop run up 33⅓ per cent. by simply always keeping castings on hand ready to go to work as soon as a man had finished his previous job, and making the standard parts in liberal quantities. If any reader of MACHINERY supposes it cost 33⅓ per cent. more to do this, let him be heard and explain how and why.

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ANGULARITY OF CONNECTING RODS.

THEO. F. SCHEFFLER, JR.

Steam-engine designers and draftsmen generally will appreciate this simple little formula for finding the exact point of cut-off in calculating at what point of the engine-stroke the steam is cut off in steam chest. All draftsmen who have ever laid out the steam-engine valve motion know that this point due to the angu-

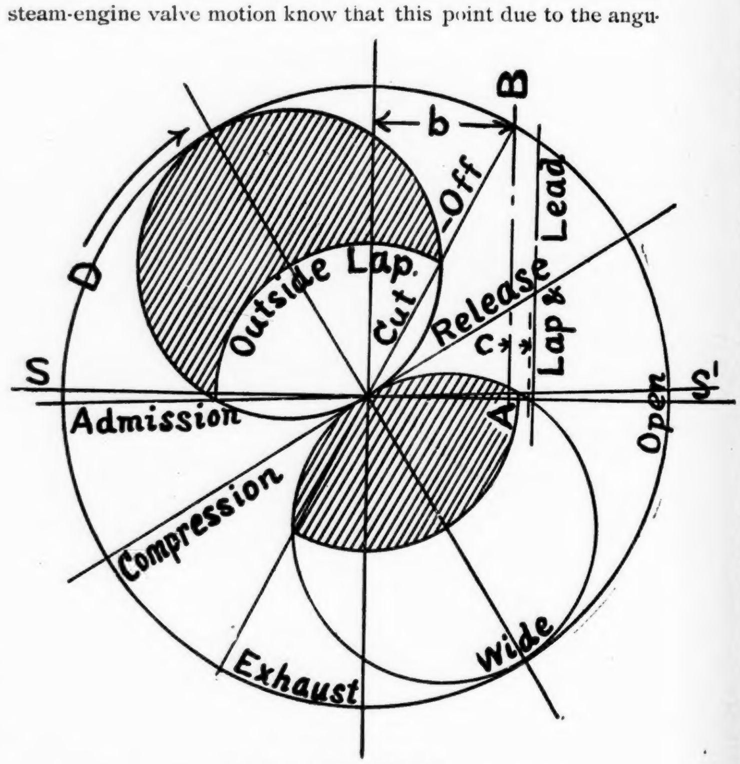


FIG. 1.—9 x 12 inch Engine.
b = Distance from center of shaft to point of cut-off on eccentric circle.
c = Difference due to angularity of connecting-rod.
Then c = .14 b.

larity of the connecting-rod can easily be found by means of a pair of trammels, or, when the drawing is not on a large scale, by a pair of large compasses with lengthening bar.

In laying out the valve motion from the Zeuner diagram, it will

be remembered that the angularity of the connecting-rod is not considered. Why this difference has not been taken into account I cannot understand, for in some cases this difference amounts to considerable in the area of the indicator card. As an illustration we have a 9×12 inch engine; travel of valve is 3¼ inch; outside lap, $\frac{13}{16}$ inch, and width of steam port, $\frac{13}{16}$ inch, with no inside lap. Fig. 1 represents the Zeuner diagram, which I find will apply to this formula very nicely. The line A B represents the point of cut-off on the crank circle D, which is also the eccentric circle. It will be observed from the diagram that the line A B is less than three-quarters of the whole stroke S S^1, as measured on the line S to the line A B. Now, in order to find the exact position

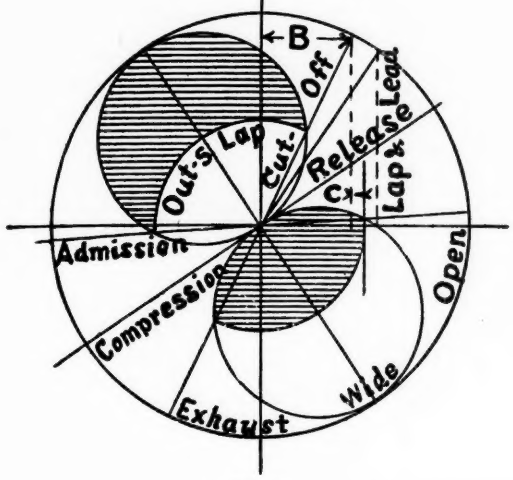


FIG. 2.

6x9 inch. Travel = 2¼ inch. Lap = $\frac{9}{16}$ inch. Port = $\frac{9}{16}$ inch. ¾ cut-off.

of the piston and what proportion of the stroke it will bear to the stroke S S, we have the following formula:

$$C = .14 B.$$

Where B = Distance from center of shaft to point of cut-off on eccentric circle; and
.14 = A constant,
C = Point of cut-off, difference due to angularity of the connecting-rod.

Example.—What will be the exact point of cut-off for the above 9×12 inch engine, with the condition named for lap, travel and width of steam port, and with $\frac{1}{16}$ inch lead.

B = in this case .751 part of an inch; therefore
C = .14 × .751 = .10514.

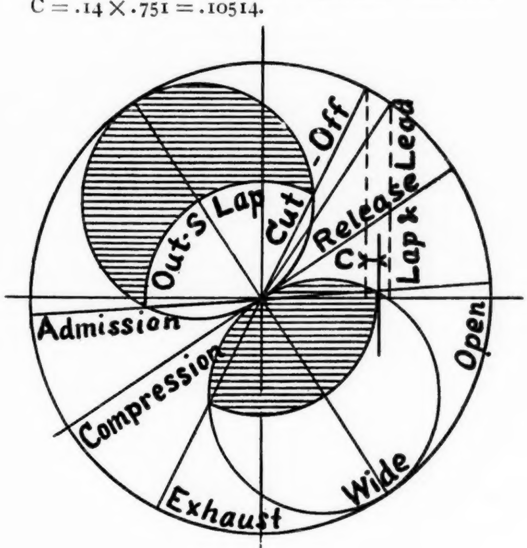


FIG. 3.

7x10 inch. Travel = 2¼ inch. Lap = ⅝ inch. Port = ⅝ inch. Cut-off = ¾ of stroke.

This sum added to the distance S is from the line A B = 2.481 inches, which is the point of cut-off and a little over three-quarters of the total stroke. Should the line A B be greater than three-quarters of the stroke, multiply .14 by the outside lap of the valve.

The writer has found from actual experience that the exact point of cut-off due to the difference of the angularity of the connecting-rod, as found by using this formula, will not vary more than $\frac{1}{200}$ part of the total stroke.

In laying out the Zeuner diagram, this formula has proved of great help, and is very easily remembered. It is very rarely that the line A B is more than three-quarters of the total stroke, and only in cases when it is desired to cut-off at over or about seven-eighths of the stroke.

For Automatic Cut-off engines, where the point of cut-off is constantly changing with the load, and also where the point of

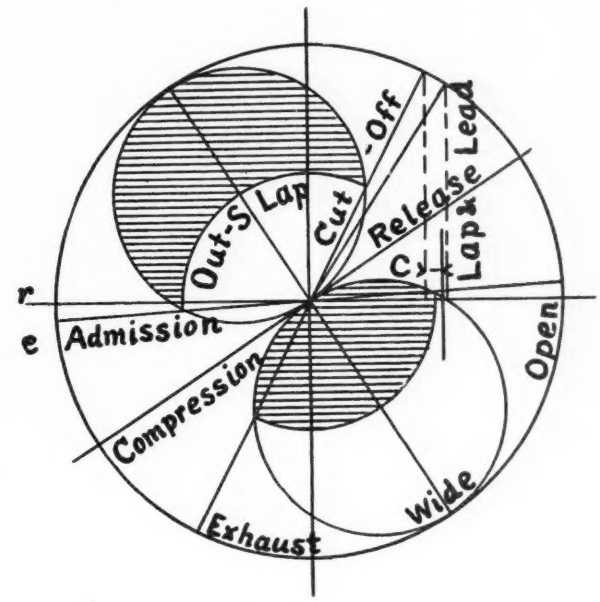


FIG. 4.

8x10 inch. Travel = 2¾ inch. Lap = $\frac{11}{16}$ inch, Port $\frac{11}{16}$ inch. Cut-off a little over ¾ of stroke.

cut-off is under three-eighths of the total stroke, we also multiply the outside lap by .14, which will give the angular difference very closely. In fact, the lap of valve I have found to come all right at all points of cut-off under one-half the stroke, and also at all points over three-sixteenths of the stroke. The intermediate points of cut-off between one-half and three-sixteenths of the stroke must be found as explained above. This formula is

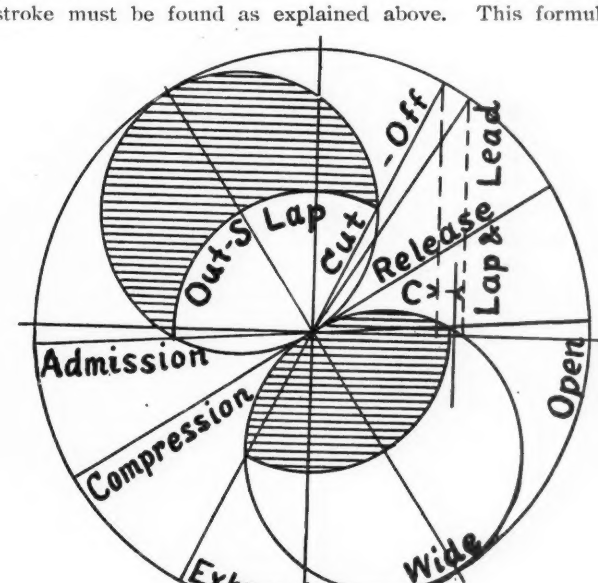


FIG. 5.

8x12 inch. Travel = 3 inch. Lap = ¾ inch. Port = ¾ inch. Cut-off = a little over ¾ of stroke.

intended for engines having connecting-rods from two and three-quarters to three times the length of the stroke, which would make it adapted for stationary engines, more so than for locomotives.

The diagrams illustrated in Figs. 2, 3, 4 and 5 have been taken from engines in actual every day practice.

* * *

Don't be like a sponge, to absorb information and give out nothing unless you are squeezed. When you get a good idea from a fellow workman or another shop, give one of yours in return; its only a fair exchange and will make them feel like giving you more on your next visit.

ERECTING AND STARTINC ENGINES.—2.

"SPIKE."

If the engine stands on smooth cut stones and you have ⅜ inch or less between the stone and casting, use soft metal for filling. Seven parts lead to one of antimony makes a metal that flows very freely, and is hard enough. If there are thin places that you have doubts about filling, throw in a little kerosene oil and pour the metal very quickly, and you will be surprised to see what a thin joint it will go into.

Another little kink comes to me here that has been a great help to me at times. If you have any bolts to lead into a hole in a stone and the hole is wet, or if you have an engine to set on wet or frosty stones, just give the surface a good coating of common bar soap and you will have no trouble with flying metal. The metal will melt the soap and crowd it out, leaving the opening as full of metal as though it had been dry.

It is or has been, pretty common practice to use cast iron chips and sal ammoniac for filling between the engine and foundation. But don't do it. The same man that recommends its use will tell you to have the chips very free from oil before mixing, and to keep the oil from it after the engine is set on it. Any one can get clean chips to start with, but I defy the best engineer on earth to keep the oil from it after the engine is started. Consequently it becomes soft and lifeless and perfectly useless.

I have had occasion to take down several old engines where iron chips have been used for filling, and found the engine setting on a few iron wedges and the filling as soft and lifeless as though it had been mixed with oil to start with.

Brimstone is another substance used for the same purpose, and I consider it good if you can get it in where you want it, but I will admit that I could never make it run into an opening with great breadth and little depth. But where there is great depth and little breadth it is all right as far as I know, although my experience with it is very limited.

If the engine sets on rough stone or brick, or for any reason there is a large opening between the engine and the foundation, use good Portland cement, and unless the opening is unusually large use the cement clear, as when it is mixed with sand it must be mixed very thin, or the sand will choke the opening and prevent the cement from filling the thinner places. And if mixed too thin the sand will separate from the cement and settle to the bottom, making an inferior job. It is also a good plan to test the cement before using, as I find that it varies in quality, and before I got in the habit of testing it I had to take up one engine that was set on iron sole-plates, remove the plates and cement and do the job over again.

A simple way of testing it is to mix a little of it thin as you would for grouting and run it into a mould, forming a stick say one inch square and six or eight inches long, and when thoroughly dry, if good cement, you will find it difficult to break it between the hands. If it breaks easily and crumbles readily and appears lifeless, don't use it, as the oil from the engine will soon make mud of it. Oil has but little effect on good cement.

After filling the joint and allowing the cement time to harden (if cement is used), tighten the foundation bolts.

Here let me introduce a little kink that saves a lot of angry words. Of course it is desirable to have all of the bolts project the same distance above the nuts, which is a very difficult thing to do ordinarily. But if you will take a set or staking tool and turn over the top of the thread part way around where you want the under side of the nut to stop, it will stop there and then act as the head of a bolt and turn into the lower nut. A better way is to cut just thread enough for the upper nut, but that is what I could never get the builders to do.

It is a very common practice among engine builders lately to build up the foundation and cap it with cast iron sole-plates with planed spots where the engine rests on them, and I believe it to be the best way to set them. And I think it is inexpensive compared with cut stone. I have set a number of engines on the iron plates and have always got a more satisfactory job than in any other way. But it is possible to make a very unsatisfactory job even with the plates. For instance, it is not unusual for the plates to be shipped ahead of the engine, so the masons can set them when they finish the foundations. But the man has my sympathy that has to set the engine on them, as I will stake my reputation against the mason's level that the plates will be taken up and reset, or else there will be a lot of shims between the plates and engine.

To have a satisfactory job get the plates on to the foundation and the engine on to the plates, and then level the engine by shimming under the plates. Then do your grouting and you will have a job that will make you happy, and it won't take as long as it will to set the engine on cut stone.

Having the frame and cylinder in place, level and in line and bolted fast, get the bed-box or an outboard bearing (as it is sometimes called) in place, and with a straight-edge level across from the crank bearing to ascertain if the bed-box is low enough. If it sets on stone I would allow at least ⅛ inch for soft metal. If on a cast iron plate, ¼ inch for cement. After satisfying yourself on these points give the crank-shaft a thin coat of red lead and oil and drop it into the boxes and level by shimming under the plate that carries the box, or between the box and stone as the case may be. Now stretch a line from j to j parallel with the line g' g'. Get a piece of board as long as you can use conveniently, say six feet, and wedge it in between crank arm and head of crank-pin, with one end projecting as far as possible, without striking the frame. At the extreme end on the outer edge drive a nail to be used as a spot to measure from. (See sketch in October.) Now place the crank on the center or with the nail the same height as the line, and measure from nail-head to the line. Then put the crank on the other center and if the distance from the nail-head to the line is the same, the shaft is at a right angle to the center line of engine. If not the same, move the bed-box until they measure alike. Then, knowing your shaft to be level, do your grouting. Then tighten the bolts that secure the bed-box and roll the box in its bearings a few times to mark the babbitt where it bears hard. Then take the shaft out and scrape the box, and continue to roll and scrape until there is a good bearing. When ready to put it in for the last time see that the bearings are well oiled before dropping it in. Now put the caps on and fill the oil-holes with waste or plugs to keep the dirt out. Then turn the shaft until the key-way is up and put the key in. Jack up the under half of the wheel until it comes in place against the shaft. Then bring the other half and let it down on to the shaft, first measuring the key and key-way to satisfy yourself that they are going together all right, as it is easier to make them right before putting the wheel on than after.

I say put the key into the shaft before putting the wheel on for various reasons. I have had experience both ways. One firm that I worked for gave me special instructions to drive the key after the wheel was on and bolted fast. I demurred, and was promptly informed that they had always done it that way, and gave me to understand that they were always going to; that the key was fitted to the wheel and shaft and marked as it belonged; and if I drove it as I found it, it would be all right. Well, I attempted to drive it as I found it, only that I tapered the end of it for about two inches, knowing that it would upset more or less in driving. Then I got a bar of steel 2¼ inches square and 18 inches long (the key was 2⅜ inches square) and hollowed the end to fit the round on the end of the key and used it for a set to drive against. Then I got a piece of 5-inch shafting 8 feet long and slung it up for a ram to drive it with. I slushed the key with white lead and lard oil mixed and started to drive with the determination to "get there" or else split the shaft or hub. I didn't succeed in doing either one of the three, although I drove the key about half way and then doubled up the set and upset the end of the key until the end was ⅛ inch larger than the rest of it. Then I unbolted the wheel, jacked up the upper half and lifted out the key with wedges, reduced the bunch on the end, drove it down into the shaft where it belonged and lowered the wheel on to it and clamped it up without any trouble and without reducing the key in the least. Time trying to put key in and getting it out again, twenty-six hours. Time putting key in and putting wheel back on, about three hours.

I claim that it is impossible to drive a large key endwise and get as durable and satisfactory results as when put into the shaft and the wheel clamped on to it. I know of another engine built by the same firm, with the key driven endwise, and one half of the wheel runs about perfect and the other half runs out $\frac{3}{16}$ of an inch, caused by the upset on the end of the key.

Let us go back to our job again and get the steam and exhaust pipes connected. If it is a condensing engine, don't connect the exhaust pipe with the condenser, but run it out either through a door or window temporarily until you get the dirt blown out of the pipes and engine. To do this satisfactorily, cover the ends of the valve chambers with a piece of plank with a bolt through

them from end to end to clamp them to the breasts, if a Wheelock engine. If a Corliss, the bonnets and their screws can be used if the long bolts are not handy to get. Put on the cylinder-head and clamp a piece of soft pine board over the stuffing-box, using the gland wrong end to for a strap. Then, having steam up, caution the fireman to look out for the water in the boiler, as when you open the throttle valve it is pretty liable to pull a stream of water as large as the steam pipe, out of the boiler. Don't keep the valve open more than a few seconds at a time, as it would take but a very few seconds to pull the water down to a dangerous level if it once gets started, but there is no objection to the water coming if it don't draw it too low in the boiler.

I believe it is not customary for engines to be blown through in this way before starting them. In fact, I have never seen or heard of its being done except by myself or those instructed by me either directly or indirectly. But I have known of a great many engines being started where it wasn't done, and have talked with others that have set up engines for a living, and they never heard of such a thing. But after seeing what I have seen come out of the exhaust pipe, I would as soon think of starting an engine without oil as without blowing it through before starting.

I remember one case in particular. The engine was a 32 × 60, and was supplied with steam from a water-tube boiler through about 90 feet of 12-inch wrought iron pipe. There was about 40 feet of 14-inch exhaust pipe which projected about 10 feet through a flat copper roof, giving a good chance to see what came through. Before starting to blow through I had the boiler filled about solid full of water and steam raised to 110 pounds, that being the working pressure. I then opened the valve a little and got the engine thoroughly warmed. Then I opened the valve wide and closed it again as soon as possible, taking possibly six or eight seconds to open and close it, but during that time it lowered the water in the boiler below the regular working level, and the stuff that was thrown on to the roof was astonishing. All of the caps over the ends of the boiler tubes, in fact all the joints about the boiler and piping, were made with Jenkins packing, and that had passed out of the joints on to the boiler and pipes and had blown out on to the roof with core, sand, boring chips, pipe scale, cotton waste, one petticoat lamp, one boiler-maker's over-jacket and cap, and chips and sticks enough to kindle a fire with, and I did think of having the pipe disconnected to see if there was a boiler-maker lodged in it anywhere, but finally decided there couldn't be, as the steam came so freely.

The proprietor was in a hurry to start the engine and didn't want me to stop to blow the dirt out of it, as he didn't think there was enough to do any harm. But after seeing what came through he admitted that there was enough to do damage that would take hundreds of dollars to repair. This I will admit was an exceptional case, but I can cite other cases where I have found enough dirt to about ruin the engine.

I happened into an electric light station in a city in Colorado a few years ago, where there were three engines just alike, about 250 H. P. each, and they were fine machines. The first one was started about three months before I was there, the second one a month later, and the last had been run with a light load the night before.

Upon going into the engine room, they had the head off No. 3, and were wondering what caused the cylinder to cut so. It was not simply cut, but just plowed from end to end, and was rebored before using again. I learned that the first one had the same record. That ran three nights and then was rebored. The second was scratched a very little, not enough to require reboring.

It seems the first and third were started with new boilers and pipe. The second with boilers that had been run a month, and ten feet of new pipe. I asked the man that set them up if he blew the dirt out before starting them, and he wanted to know what dirt. The reader can draw his own conclusions.

To offset all of this I have known of engines being started and have started them myself, without first being blown through, and not a scratch in cylinder or valve seat. But I believe it is running too great a risk.

There is another point I want to mention in regard to starting a new engine, that is in warming it up. That is something that should be done very slowly. The best way that I know of is to start a slow fire under the boiler, open the valves between boiler and engine, also inlet and outlet valves, and let the steam get everything hot before there is any pressure. At the same time take your wrenches and tighten up all the joints, and don't be satisfied with going over them once, but keep at them until there is absolutely no more, and don't slight the ones that are hard to get at. It is cheaper to have a special wrench made than to let the gasket blow out. After being heated the first time and cooled down, try the bolts again.

I don't think I can say anything in regard to putting in the valves and piston and connecting up the rods, as those have all been together in the shop. But the one thing to guard against is any cramp or bind in the valve or regulator rod connections. They are sure to make trouble if not perfectly free.

Before starting the engine with steam be sure and roll it one full turn by hand, and watch closely when it passes either center and see that the piston doesn't strike either head. In fact watch the whole engine for the entire revolution, and be sure all of the parts are adjusted as they should be. After being satisfied that everything is right, unhook the valve gear from the eccentric and work the valves by hand for the first few revolutions with steam. Everything appearing all right, drop in the hook and let it roll, but keep a close watch of it for two or three days.

I want to say a few words about oil channels. I have been called a "crank" on the subject, and I suppose I am. But I had rather not have any channels than to have one that isn't cut clear through to the end of the bearing. Give me a channel with an outlet as large or larger than the inlet. Why? Because.

Did you ever see any common, everyday engine oil without more or less dirt in it? You may have seen a sample that some oil drummer brings with him that is pretty free from it. But knock the head out of the first barrel that he sends you and see what is in the bottom after using the oil. Now if the channel isn't cut clear through, what dirt goes into the oil-hole, whether with or without the oil, will be washed to the far end of the channel and stop there, and the next dirt that comes in stops there too, and so on until the channel is full. And then what? A hot box, of course.

On the other hand, if the channel has an outlet the dirt goes out and loses itself on the floor. Do I hear some one say, "And the oil follows after and makes itself very conspicuous on the floor." All right, reduce the feed and save oil by it. Some one else says, "What is the channel for except to hold oil." It is not to hold oil, but to distribute it, and if it won't distribute it the whole length of the bearing, what good is it?

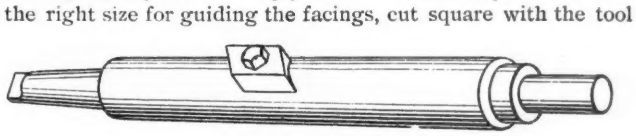
I believe it to be good practice to slush the bore of the cylinder with plumbago mixed with cylinder oil, before putting the piston in, and also to inject the same by means of the oil-pump for the first few days' run, as by so doing you will get a better and more lasting surface on the cylinder than it is possible to get in any other way.

Don't try to economize on oil for the first few days, as it is apt to be expensive economy.

* * *

A HANDY FACING BAR.

The bar shown with this is used by Mr. T. R. Almond in facing some of the cast iron portions of his quarter turn coupling, and is such a simple and easily made tool that it is of interest to mechanics generally. It is simply a bar of machinery steel turned to the right size for guiding the facings, cut square with the tool



HANDY FACING BAR.

and having a threaded hole tapped in it at the required place for the facing cutter. The cutter is simply a piece of square bar steel, milled to fit the curvature of the bar and having the ends beveled for cutting edges as shown. This is held to the bar by the cap screw shown, and as it can easily be reversed, two cutting edges are at hand and can be used without stopping in the middle of a job to grind the cutter. It can well be adapted by those having work of this kind to do and is sure to be found a useful tool in almost any shop.

* * *

The *American Engineer and Railroad Journal* announces that after November 1, 1895, the paper will be issued as a bi-weekly, appearing every alternate Thursday. Each issue will contain one-half its present amount of reading matter and the price will be reduced to 10 cents per copy or $2.50 per year, foreign subscriptions, $3.50. Success to the new form.

PRACTICAL PROBLEMS.

JOHN T. USHER.

Mr. Otto E. Evans, York, Neb., submits the devices shown in Figs. 1 to 5 as solutions of problems 1 and 2.

Figs. 1 and 2 represent Mr. Evans' solution of problem 1, showing semi-sectional front and side elevation respectively of the assembled parts. The arbor (for the cutters 5 and 6) is keyed in the stepped gear-wheel 2, which is journaled on the periphery and sides *a a* of the steps, in the journal-box 3, 4. The gear deriving its motion from a pinion on the splined shaft 7 (Fig. 2), the pitch lines of the pinion and gear being shown by dotted lines.

The above device covers all the requirements of the problem, and could be made to accomplish its purpose very effectively. It would require considerable power to drive it on account of excessive diameter of the bearing. But, on the other hand, the large diameter of the bearing would serve to steady the arbor and cutters. If the device was made as shown in the figures, there would be a possibility of the dust from the casting and chips getting into bearings, but by the employment of suitable means this could be avoided.

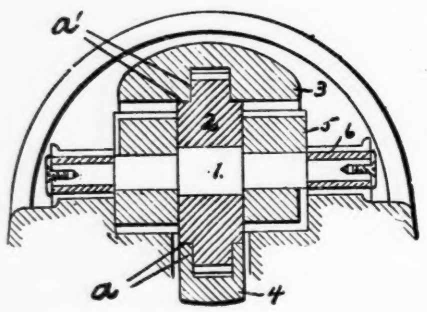


FIG. 1

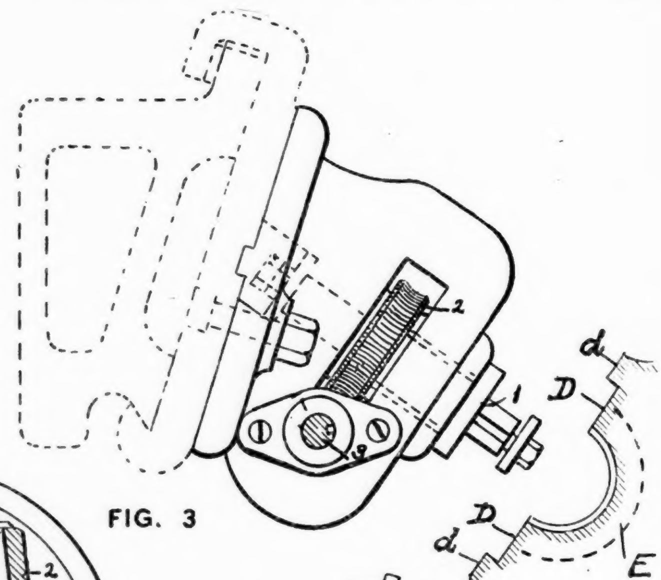


FIG. 3

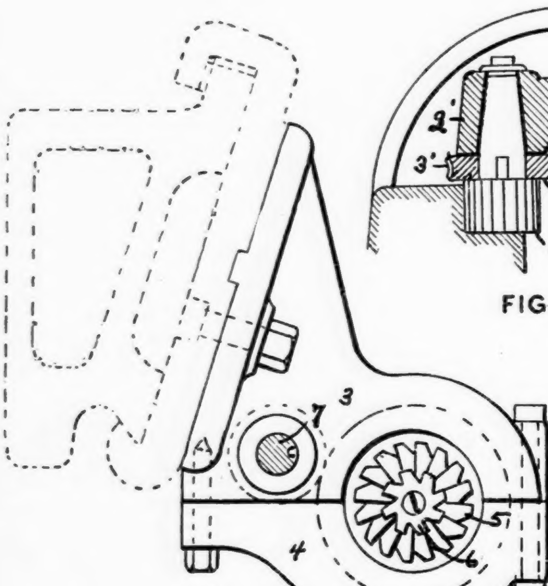


FIG. 2

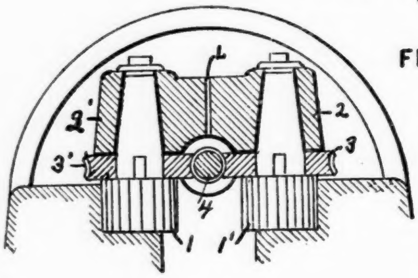


FIG. 4

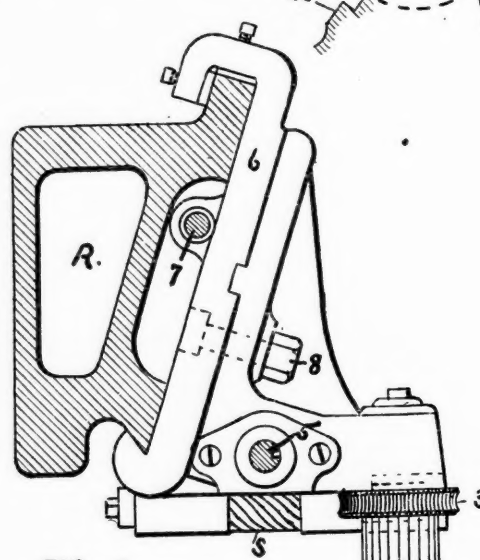


FIG. 5

In Fig. 3 Mr. Evans offers an excellent solution of problem 2, which is shown so plainly as to its construction, etc., that a further description of it (except as furnished by Mr. Evans later on) is unnecessary.

Figs. 4 and 5 are semi-sectional front and side elevations of another solution of problem 1 submitted by Mr. Evans, which is intended to mill the guides of an engine-bed constructed on the same lines, but with the flanges B C (problem 1) omitted in its design. The explanation and purpose of the device is given below in Mr. Evans' own words.

Figs. 4 and 5 show a device for milling the guides of a bed of a slightly different design. In this design only two surfaces on each side are milled, and this is done by two vertical (end) mills 1 and 1', having worm gears 3 and 3' attached, and receiving motion from worm 4, which is in turn driven from the splined shaft 5 (Fig. 5), by means of spiral gears, spiral gear on shaft 4 being shown at S. Mr. Evans then proceeds to comment on this device as follows:—

"If the main casting of this attachment (device) had been made in two pieces and bolted together, the parting vertical, and at oil-hole 4, the original distance between vertical sides milled could be maintained through the various stages of wear of mills, and I think distance pieces could be bolted between the parts 2 and 2' and would enable the same attachment to mill two or more sizes of beds.

"In the design of these attachments the shop is supposed to be in possession of a milling machine of the type indicated by the section of cross-rail R (Fig. 5), and that engines are the main product. The tail support as furnished with the machine is to be removed permanently, a saddle 6 (Fig. 5) is fitted to cross-rail and is tapped for cross-feed screw 7. To this saddle is fitted the various attachments, including a new tail-support for the arbors in regular work, and a vertical spindle milling attachment.

"The ends of the boxes could be milled with the latter attachment, or with a suitable mill on Fig. 3. If the engine bed were of the design shown in section in Fig. 4, the distance between hubs of boxes could be made the same as vertical surfaces of guides, and both milled at one operation."

It is evident from the description and drawings of the above solutions that Mr. Evans has adapted them to the inclined cross-rail of the Ingersoll milling machine, and that in their application he has retained and utilized the original driving motion of the machine. Each of the devices are, however, equally adaptable to other types of milling machines and also to planing machines.

Referring to Mr. Evans' suggestion regarding the extensibility of the device shown in Figs. 4 and 5, where distance-pieces are be

be inserted to compensate for the wear of the cutters, to maintain the standard of the work, and to admit of the same device being employed for milling two or more sizes of beds. It should be borne in mind that just as soon as any change is made in this respect, the device would become faulty, if not in operative, unless the diameter of either the worm or worm-wheels was relatively increased. By retaining the basal principles of the device the feature of its extensibility could be more effectively and readily secured by other means. But I do not as yet feel at liberty to show how it can be accomplished, as such a suggestion might possibly interfere with other solutions that are likely to be submitted. Should no similar solution be submitted I will at the close of this problem submit a plan by which this device can, as Mr. Evans suggests, be adjusted for wear, or be used for milling two or more sizes of beds.

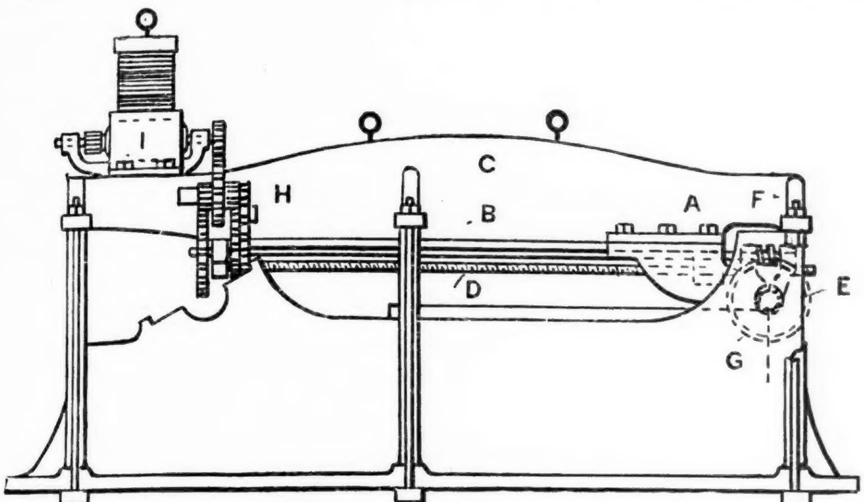


FIG. 6

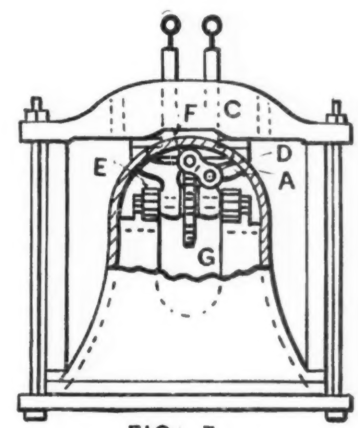


FIG. 7

Regarding Mr. Evans' suggestion to proportion the measurements of the guides and bearings to suit the cutters, I do not think that in this case such a suggestion could be entertained, as there are other and more important considerations which necessarily enter into the designing and proportioning of an engine, than the machining of the parts. In fact, it is purely and simply a question of designing the tools to suit the work; and this Mr. Evans has accomplished in a satisfactory manner.

Figs. 6 and 7 represent side and end (partly in section) elevation of a very ingenious solution of problem 1, submitted by Mr. W. J. Ball, Oregon, Wis., which I regret to say does not come within the restrictions of the problem at all, inasmuch as it is not applicable as an attachment to either the planing or milling machines.

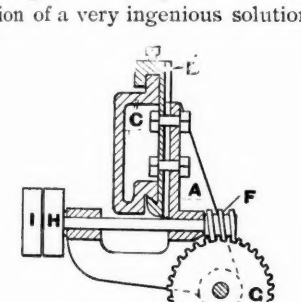


FIG. 8

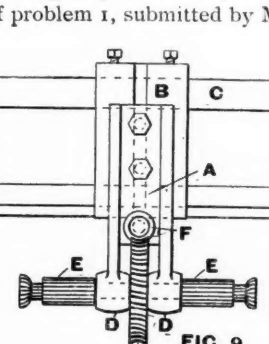


FIG. 9

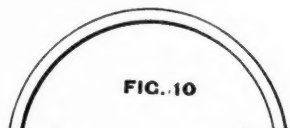


FIG. 10

This device is shown (by request) first, on account of its novelty, and secondly, because it really does contain a practical solution of the problem.

As shown in Figs. 6 and 7, it is designed to be applied directly on the engine bed. It is self-contained, inasmuch as it possesses all the requisites of a complete machine; with the exception of the supports—which are to say the least faulty. It should have been arranged in such manner as to be supported directly on the bed itself, or otherwise upon suitable standards, instead of being supported upon the wooden-props, as shown. The device consists of a sliding cutter-head A, which is traversed along the slides B on the frame C by means of the feed-screw D. The cutters E are driven by the worm-shaft and worm F and worm-wheel G from the gearing H, which receives motion from the electric motor I.

In the worm-shaft and worm F and cutter-head A we have however, a very neat and efficient solution of problem 1; which can be very easily adapted to the cross-rail of either the planing or milling machine.

The adaptation of the above device to the cross-rail of a planer is shown in Figs. 8 and 9, A A representing the cutter-head bolted to the saddle B of the cross-rail C. The arbor for the cutters E E is journaled in the bearings D D, and is driven by the worm-wheel G from the worm-shaft and worm F. The worm-shaft, which extends on the under side to the back of the cross-rail, is driven from a counter-shaft by the pulley H, the motor for driving being shown at I.

In showing how Mr. Ball's solution of problem 1 can be applied on the cross-rail of a planer or milling machine, no change has been made in the device itself and, therefore, it should not conflict with any solution which may be hereafter presented.

As there appears to have been a misconception of the requirements of problem 1, Fig. 10 (which is a cross section of the guides and hood) is shown herewith, to make the requirements more clear. This, however, in the solutions presented, is only a matter of changing the form of the cutters.

* *

ENGINE ROOM NOTES.

THE MOST ECONOMICAL PRESSURE TO CARRY.

W. H. Wakeman.

Several times the question as to the most economical pressure to carry on a boiler, has been referred to me and in almost every case the inquirer seems to expect that an unqualified answer will be given, and when it is not, he is disappointed. One acquaintance went so far as to state that he thought that all of the boilers in a certain city should carry the same pressure, instead of varying in different places from 40 to 125 pounds. He stated that a large corporation who operated many boilers in that same vicinity, carried the same pressure on all of them and thought it to be a good idea. If this is true it may be because they are all run under similar conditions and being of the same type, and built about alike it will do to carry the same pressure on all of them, but this is very different from taking the boilers of a large city and putting them all on the same basis. In one place we find a battery of new steel boilers, made of plates $\frac{3}{8}$ inch thick with double welt butt joints, well braced and thoroughly made in every way. On them it is perfectly safe to carry 125 pounds pressure, but in another place the boilers are made of iron of a medium grade, the plates are $\frac{5}{16}$ inch thick, or rather they were when new, while now in places they are but $\frac{1}{4}$ inch thick, the joints or seams are of the double riveted type of an inferior design, and the whole battery has been used and abused for the past twenty years. They certainly are not safe at anything above 75 pounds pressure, and perhaps at not more than 60 pounds. If we are to adopt a uniform pressure for all, we must reduce the pressure on the new boilers to 60 pounds, for we cannot think of raising it on the old ones to 125 pounds, neither can we meet them half way and make it 100 pounds for all. Furthermore the needs of the two places may be entirely different, so that no one

rule will apply to both. In one place we may have a triple expansion engine with a heavy load so that we must have every pound of steam that can safely be carried on the boilers, and in the other we may have a simple engine that is much too large for the load that it has to carry, so that we could not actually use to good advantage, more than 60 pounds pressure if we had it. The plan of making the pressures uniform in all such cases is absurd on the face of it.

But the engineer is in search of information that will assist him in operating his plant with the least expenditure of money, and so he wants to know what pressure will suit his case best. It is assumed that he has an automatic engine, and so far as a single stroke of the engine is concerned, it is best to get as near boiler pressure as we can at the commencement of the stroke, and this pressure should be high as possible. The engine should be large enough to allow cut-off to take place very early in the stroke, so it will be expanded nearly to a vacuum at the end of the stroke. In this way we shall use up all of the heat available, but as before mentioned this applies to one stroke of the engine only. If our steam is expanded down very low at the end of the stroke, the temperature of the cylinder will be affected by it, and when a charge of live steam is admitted to make another stroke, a portion of it will be condensed in warming up the cylinder again. This will make the engine less efficient, and in order to overcome this difficulty, we must have a higher terminal pressure, which calls for a later cut-off. Thus the engineer finds himself between the two horns of a dilemma, for a very high or a very low terminal pressure is not good practice, but a medium between the two must be adopted, hence the rule to determine

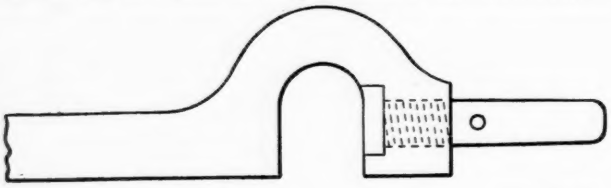


FIG. 1

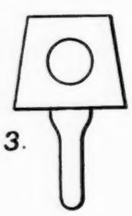


FIG 3.

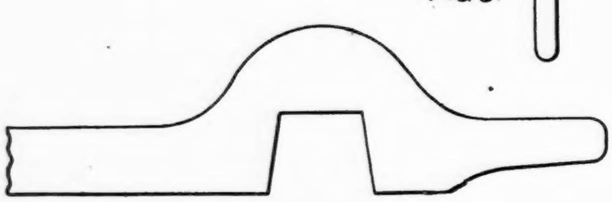


FIG. 2.

IMPROVED VALVE ROD HOOKS.

the most economical pressure to carry for an automatic, non-condensing engine. The initial pressure and point of cut-off should be so arranged as to give a terminal pressure not lower than the atmosphere nor more than 5 pounds above it. Like every other rule there are exceptions to it, for if we have an engine that is too large for the load, we cannot adopt this rule, for it would call for an initial pressure so low as to be impracticable, and on the other hand, if our engine is overloaded, this rule would call for such a high pressure that our boilers could not safely carry it, therefore the rule will apply only to limited conditions, but it is as good a rule as can be devised. Incidentally I will remark that this statement of affairs leads on to an explanation of the cause of the economy of the compound engine, for the range of temperature in each cylinder is much less than if only one cylinder is provided in which the total number of expansions must take place.

The question is frequently asked if it is possible for the temperature in a cylinder to rise and fall twice during every revolution of the engine, to correspond with the variations in the pressure, and to this I would reply that it may be possible, but it is not probable, although I am sure that the temperature varies greatly in the ordinary steam engine cylinder.

IMPROVED VALVE ROD HOOKS.

Engineers in charge of Corliss engines, or of any other type where the valve rod hooks on to a stud in the wrist plate or any similar device, are always annoyed by the noise caused by the lost motion in the hook, unless there are other noises in the room which are more prominent, for the small wearing surface presented by the hook is soon worn by the continual motion of the wrist plate, and as a rule there is no way provided to take up this lost motion, so after it gets to be an intolerable nuisance a new "thimble" is made and slipped on to the stud, the hook is filed out and fitted to this thimble and the noise disappears for a time.

In order to overcome this difficulty an engine builder devised a hook which is shown in Fig. 1. It is made in three parts, for the bearing on one side is movable, as shown in the cut, and the handle of the hook is made in a separate piece and screwed into the main body of the hook until it engages the sliding half bearing and clamps it on to the thimble on the stud, thus holding it fast and preventing all lost motion. Holes are bored in the adjustable handle into which a lever about 8 inches long is inserted for the purpose of screwing it up tightly. In this way a full bearing on the stud is secured, instead of the very small wearing surface presented by a solid hook.

An objection to this arrangement is found in the fact that a lever must be used to fasten it into place, and also to loosen it, which is inconvenient. To obviate this difficulty an engineer has made a hook which is nearly square instead of semi-circular in form, as shown in Fig. 2. Instead of a round "thimble" on the stud, he uses a block which is nearly square externally, but which is a sliding fit on the stud in the wrist plate. See Fig. 3.

The small handle shown is to keep the block from turning over when the rod is unhooked, for, as before mentioned, this block is not square, but is in the form of a quadrangle, to which the hook is nicely fitted so that it does not bottom on it, but binds on the tapering part, although it can easily be unhooked when necessary.

A valve hook made in this way will last indefinitely, proving a source of satisfaction to both maker and user.

* * *

NOTES FROM NOTOWN.—5.

Ichabod Podunk.

It doesn't do to get the idea that you are the only man in the world or even in the shop who knows how to grind tools or to get work out in a hurry.

We have an old chap here now who came along as a tramp machinist and was hired to help out on a rush job, and who went to work with young Bob Owens, a good hand, who can hustle almost any man in the shop, the writer included. They were turning up valve stems and bonnets; the stems being machinery steel and the bonnets cast iron as usual.

Bob smiled to himself when the old man was put to work with him, and told some of the boys "he guessed he'd make the old man sweat a little to keep up with him."

They went to work on the bonnets, and while Bob was hunting up a diamond point tool that just suited him as to shape, clearance, rake, etc., the old man found a side facing tool and started in. He locked it solidly in the tool post with top of cutting edge about even with the centers, threw in the carriage feed and the side tool started to walk into the cast iron in great shape. He had found a tool with very little side clearance, so not to catch and dig into the work, and was taking a cut about ¼ of an inch deep and leaving just enough to finish. Everybody watched him work, for this was rank heresy here; the idea of using a side tool for roughing was never thought of.

Bob came back with his diamond point, but to save his life he couldn't catch the old man. When he tried to force the work the tool wouldn't stand and he was forced to admit himself beaten on that job.

When it came to finishing, the old man used a diamond point with the side cutting and finished in one cut. For the valve stems he took an old diamond point and rounded off the nose, giving considerable top rake, and this cut in good shape for roughing; the same finishing tool as before being used.

When he got time to make tools as he wanted them, he made a tool that was very much like the one shown in Fig. 3 on page 3 of the June issue of Machinery. This proved to be a good tool for almost any work and soon found favor among the boys. The old man has become a favorite and has given us many points that help in the work. The rush job is over, but the old man is likely to stay with us as long as he wants to; he has so many good ideas that he is very handy to have around.

It's a mystery to me how some men get along in the shop as

machinists. They seem to lack imagination or ingenuity and can't see anything in their mind—draw a mental picture as it were, to save them. You must make everything in solid metal and make it work before they can see the point, and even then they can't run the machine unless you stand over them and tell them just what moves to make. We sold a new machine last week and sent it to the Brass Fixture Company's shop, which is supposed to be up-to-date and have a good set of men. It was a special machine, to be sure, but as it was first cousin to a turret lathe and also some relation to a Fox lathe (both of which they had in large numbers) we never dreamed of sending a man to start it up. But word came to send some one to start it and I was sent. They had it belted up, but not a man in the place thought he could run it and it hadn't been touched. It was a simple affair to put a piece

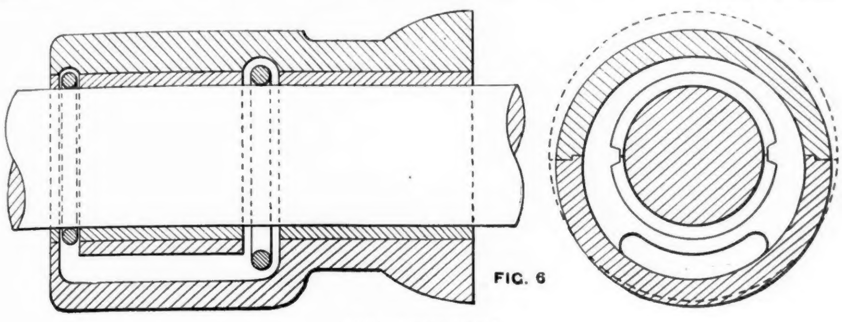


FIG. 6

AMONG THE SHOPS.

of work in the chuck, start up the lathe, bring the tools into position and finish the piece. Any boy in the shop could have done the work, and it does seem as though any foreman who hasn't gumption enough to have a new lathe started without sending for the builder wasn't the right man for the place. I don't pretend to be a bit smarter than any other wide-awake mechanic, but if I can't run any machine tool that is built for regular machine shop work I'll hire out for a purchasing agent; they don't have to know anything but dollars and cents. Of course I can't run a special tool I never saw before as fast or as well as an expert, but I can find out which screw moves this part, what controls that motion, etc., etc., and I don't send for any builder to start a new lathe as long as my name is I. Podunk, Esq., of Notown.

There is a bad case of "relations" in the next shop and it ought to be a lesson to every one in town. Two of the foremen have their sons working for them, while the proprietor's brother is the horrible example of the place. He was imported especially to be general foreman of the shop, but was actualty too lazy to look after it and voluntarily resigned to be store-keeper, so he could have more time for reading and sleeping during working hours. The foundry foreman kept his boy pretty close to business, but made the mistake of not letting him do any of the dirty work; cleaning the rumbler, etc., which is the bane of some foundries. The other foreman never made any distinction whatever between his boy and the rest, and he had to hustle castings, sweep the floor, and get dirty like the rest of the boys, and it did him good. He soon saw that his father was right, and that people expected favoritism and were disappointed not to see it. It taught him to be punctual, not to shirk any disagreeable work, and as a consequence he is fast making a good mechanic, who will know more and be more manly than if he had been shielded from all the hard work.

But the brother is the worst of all; and the proprietor does not realize that his influence is very pernicious in many ways, and that he would be better off financially if he paid him his salary to stay away from the shop. Delayed work and preventing the employment of a more profitable man are actual cash losses due to this cause. But as he makes fun for the boys, he isn't without his use I suppose.

It doesn't take more than a 25 cent microscope to see that the moral is to take no recognition of relationship in the shop or in other business dealings. Employ all the sons and brothers you choose, but don't let any one know it from any difference in treatment; if you're mean enough to "squeeze" any workman, squeeze the brother too—he'll kick and let you know how mean you are—the other chap might not dare to. Favoritism in the shop (or anywhere else for that matter) is a bad thing and *unfair* to all concerned. If your son works for you, forget he is any relation during working hours, or else treat all the other boys as sons too. It's only honesty and square dealing and is better for the boys themselves.

There are some alleged managers and superintendents of shops who have an idea they have nothing to learn and that they are doing a traveling man a favor when they give him twenty minutes of their valuable time, which might otherwise have been spent in wearing out shoe leather walking up and down the shop. Perhaps it is a condescension; but, as a rule, the courteous manager can get enough information from a bright traveling man to more than pay for the time occupied. Our Mr. B. always greets a "drummer" for machine tools or supplies with an open hand and makes him feel at home, and even if he never buys a cents worth the drummer thinks he is all right.

When a man who has mechanical tastes is traveling from place to place he picks up a great deal of information, and is willing to impart some of it when he meets another mechanic who is inclined to be cordial and who knows enough to ask the right kind of questions. There is much to be learned in this way if the men in charge of shops will only be a little agreeable and not imagine that salesmen are beggars or worse. It's a good plan to try and imagine how you would feel in a similar position.

* * *

AMONG THE SHOPS.

It is surprising what improvements can be made in a shop, with very little expense, if the foreman knows enough, has the requisite authority and is interested in his work. I know of no better example of this than in the shop of what is now the American Wheelock Engine Co., of Worcester, where, while it is not as yet fully equipped with modern tools (but will be in the near future), the change that has taken place in the general appearance of the shop, as well as its methods and production, does credit to its foreman, Mr. Frank E. Harthan.

It is so changed that those acquainted with it two years ago would hardly know it. The floors are clean, the various parts (finished and unfinished) are kept as little in the way as possible, the tools are clean and the whole appearance denotes order and system in place of its opposite. The product of some of the machines has nearly doubled and will be still more increased as the men become accustomed to the new surroundings, and it can safely be said that nearly all of this can be attributed to good management and a thoroughly capable foreman, who has not only renovated the shop, but (what is harder still) has kept it so.

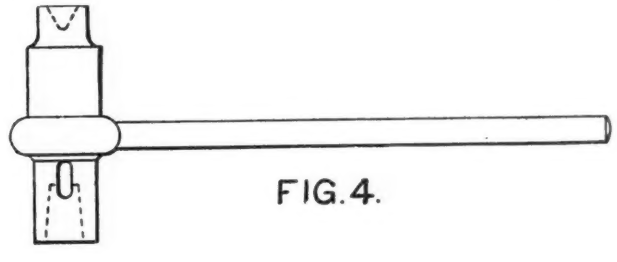


FIG. 4.

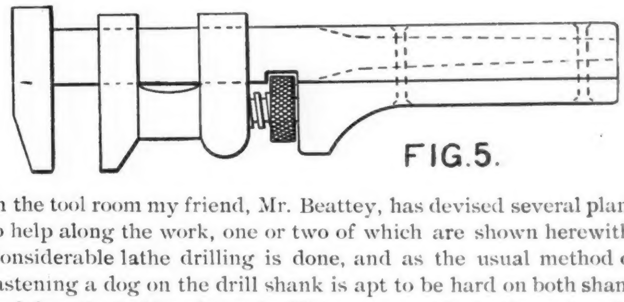


FIG. 5.

In the tool room my friend, Mr. Beattey, has devised several plans to help along the work, one or two of which are shown herewith. Considerable lathe drilling is done, and as the usual method of fastening a dog on the drill shank is apt to be hard on both shank and dog, the holder shown in Fig. 4 was made in three sizes for as many sizes of shanks, these being used for twist drills. It is well liked, and where this class of work is done, will save drills enough to pay for itself. The cut needs no explanation, as it will be readily understood by any mechanic; the handle is made separately and slipped over the head or shank. Another plan on this same line is to make sockets to hold drills which have had the tangs twisted off, as will sometimes happen. These are simply shorter sockets with the slotted portion fitted to receive new

tangs ground on the drill shanks, and save a good many drills from being sent to the scrap heap, while still in their prime so far as cutting edge is concerned. The ordinary monkey wrench is not calculated with a large enough factor of safety to admit of a 10-foot pipe being added to the handle, and Mr. Beattey has reinforced them as shown in the sketch, doing away with the wooden handle and its numerous breakages. Most shopmen know the annoyance, delay and danger due to a counter which will not run cool, and while most of the trouble is caused by a loose pulley with insufficient bearing, the boxes are occasionally

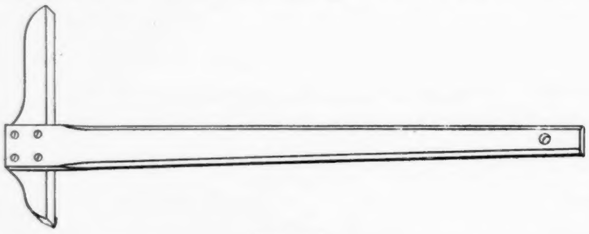


FIGURE 7.

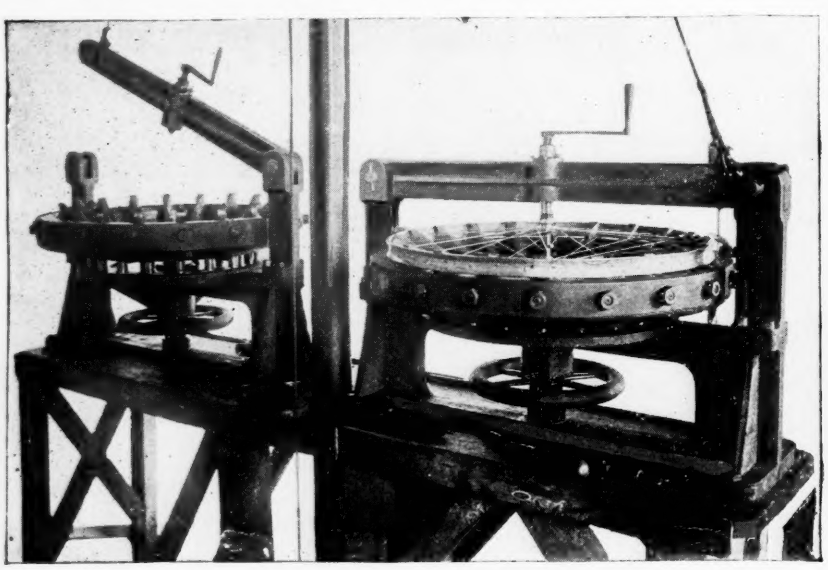
responsible. Having one such on a planer which was much in demand, Mr. Harthan got out new boxes for it, as shown in Fig. 6, which affords a long bearing and a good reservoir with self-oiling rings. The box is babbitt lined and has a brass ring on each end which fits snugly on the shaft to prevent the oil working out of the end of the box, the centrifugal force throwing it into the recess from which it drains back to the reservoir. The oiling rings are also brass and located so as to give the oil a practically even distribution lengthwise. In the drafting room, which recalls many pleasant recollections, I found a form of Tee square being tried by Chief Draftsman Jenness, at the suggestion of Mr. Philip Pistor, who looks after the designing at the Philadelphia end of the concern. Fig. 7 shows the idea, which consists of attaching the blade at a point considerably below the center of the head. This will be found a great convenience in working at the lower edge cf the drawing board, while foı any other position (except the extreme top of board) it is just as convenient as any square. It is certainly worth a trial and will be found to give good results. F. H. C.

* * *

A VISIT TO A BICYCLE FACTORY.

FRED H. COLVIN.

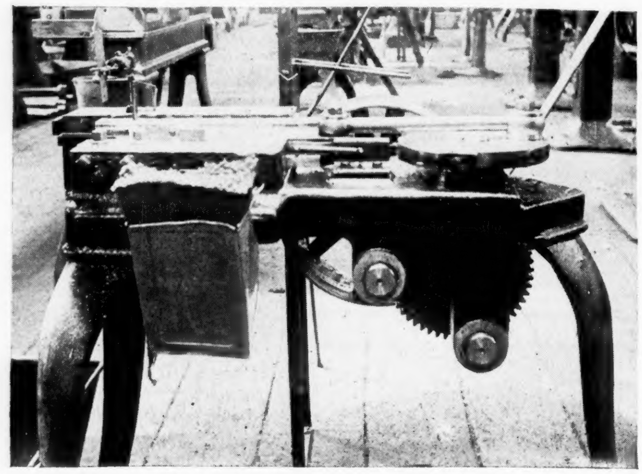
Bicycling has become such a popular method of travel that a visit to one of the factories where they are made will probably interest many, as it did the writer; particularly as an old friend of his is the superintendent, and took particular pains to show him all the interesting points, although all cannot be told at this writing. The factory is that of the Liberty Cycle Co., at Rockaway, N. J., although before this appears in print they expect to be occupying more commodious quarters at Bridgeport, Conn. The



WHEEL TRUING MACHINE. FIG. 1.

superintendent is Mr. Frederick Schrader, a thorough mechanic, who has worked his way up by virtue of his ability; and who, by the way, was one of the best road riders of the old Star bicycle I know of, we having ridden many a mile together on wheels weighing 50 and 70 pounds respectively, back in the early '80's—quite a contrast from the 17 to 23 pound Liberty's which they are now building.

The wheels give a good starting point, and they are put together in the machines shown in Fig. 1, which were designed by



SPOKE THREADER. FIG. 2.

the superintendent. In fact, so many of the features shown are of Mr. Schrader's design that it may be easier to call attention to them as a whole.

The wheels, which have been merely put together, but the

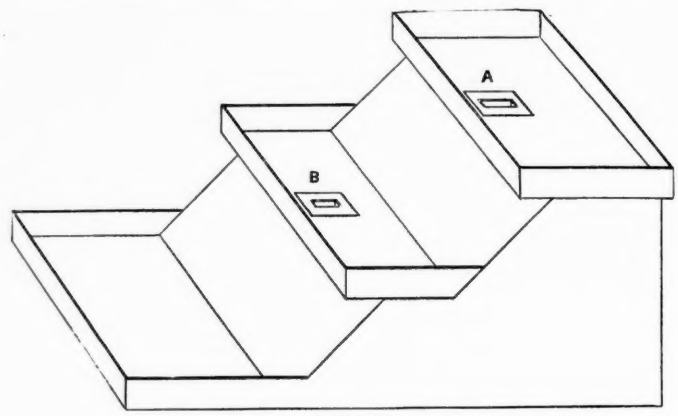
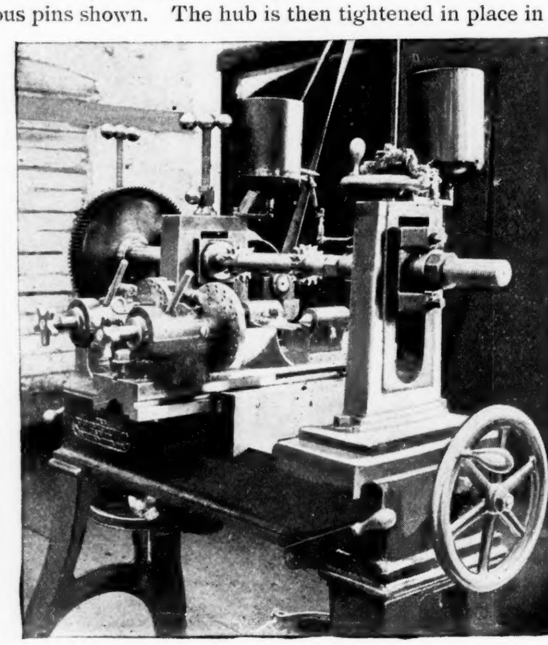


FIG. 4

spokes not tightened or trued in any way, are placed in the machine and clamped by the wheel beneath, which acts by raising the plate and thereby forcing the clamps to the rims by means of the numerous pins shown. The hub is then tightened in place in



MILLING SPROCKETS. FIG. 7.

the center of the rim and the nipples on the spokes tightened by one of the quick-thread screw drivers, which are so handy, the same as used for small drills in many cases. The wheel is thus quickly tightened up and requires very little further "truing," as the machine does its work very perfectly. The best of spoke wire

is used, and each lot of wire is tested to stand 650 pounds per spoke, making a very rigid wheel. The spokes are threaded in a little machine (by Blake & Johnson, I believe), which is shown in Fig. 2. The Simonds forging principle is used, consisting of two flat dies having straight grooves cut in them, one of which is moved by the other by the crank shown at the right and which probably runs 100 or 120 turns per minute. The spokes are fed into the machine by a boy and dropped into the pan at the left; the day's work being about as many as the boy can feed, threading 6,000 a day as an average. This makes a good, sharp thread, does not remove any metal, but instead forces the top of the threads to about .02 larger diameter than the spoke itself. In this connection the little device shown in Fig. 3 illustrates a neat kink used in heading spokes. The gage shown is forced over the hole in the bottom die-block by the spring at the left, and the spoke is inserted till it strikes the die, then is clamped. The descent of the plunger or ram forces the gage back out of the way and heads the spoke, the gage returning to place as the ram ascends.

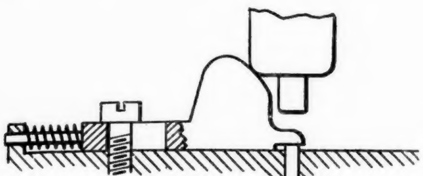


FIG. 3

The chain department is interesting, and after the blocks are cut they are tested with the rather novel limit gage shown in Fig. 4. This is built of wood with three trays as shown, the limit gages A and B being fastened in the overhanging portions of the upper trays. The blocks being placed in the top tray, the boy tries them in the gage, and all that go through land in the middle tray; those too large are rejected to be ground to size. After trying all in the top gage those on the second tray are tried, and in this case all that go through are thrown away as being too small to use. The difference between the gages is the limit of variation, which is a very few thousandths of an inch. Chains are then assembled and passed between the rollers of an ingenious little machine which rivets and rounds the heads of the pins which connect the links. From here they go to the testing machine shown in Fig. 5, which has two regular sprocket wheels and a tightener between them controlled by the handle shown. The small sprocket is connected to a small pulley, which has a friction strap controlled by the arm to the right, carrying weights to any desired amount—sort of a Prony brake arrangement. This allows the chain to be tested as severely as desired.

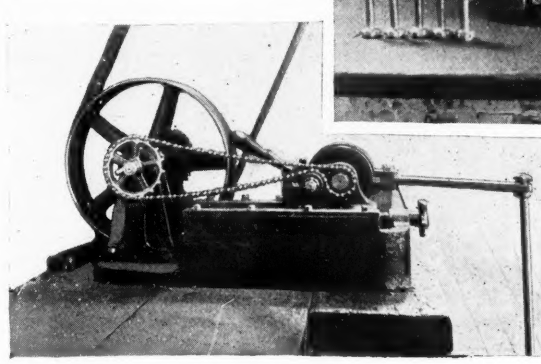


FIG. 5.

A neat little machine for drilling the rather peculiar hubs of the Liberty wheels is shown in Fig. 6. These hubs have flanges with what might be called teeth, each tooth holding two spokes running in opposite directions, and the spokes are thus truly tangent and also perfectly straight, no bend being needed as in most constructions, and aiding in making an exceptionally stiff wheel. The machine consists of two spindles, independently driven, which are rightly located with reference to the desired position of the holes and moved to and from the work by the handle at the right, the hub being held on a spindle at right angles to the drills as shown. The sprockets are milled, two at a time, on a Lincoln miller by using the double index and centers shown in Fig. 7, making a rapid method of doing this work.

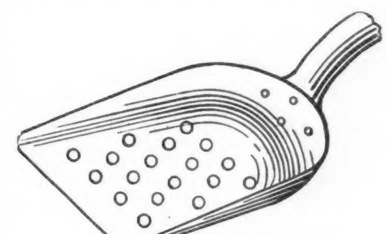


FIG. 10

One of the most ingenious kinks devised by Mr. Schrader is the magnetic holder shown in Fig. 8, for holding thin steel pedal plates for polishing. This is simply a section of wrought iron pipe of the right size, cut out to approximately fit the plate and wound with a magnetizing coil of wire as shown. Connecting it to a little dynamo in one corner of the room the buffer can hold with ease any thin piece of this shape, without any of the annoyance so usual in this kind of work. The magnetism holds it firmly to place and the notches aid it in preventing end motion. These are cheaply made, and can be used in a variety of places, the suggestion is one that should be heeded if it can be used.

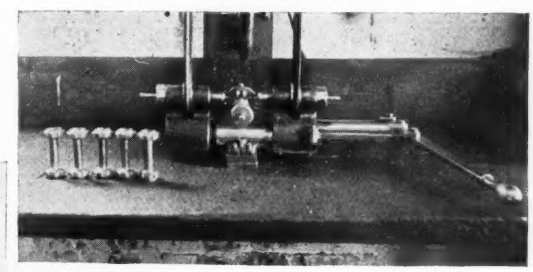


FIG. 6.

A very neat device for reversing the motion of the head is shown in Fig. 9. This is used for reversing the tap in tapping small nipples, which are held in an Almond chuck in the back head. The dog is connected to the back head (which moves on the ways), and when it has been drawn in far enough to strike the stop, it throws the bell-crank and trips the rod, which is thrown by the spring toward the left, throwing, through the lever, the clutch into the reverse position.

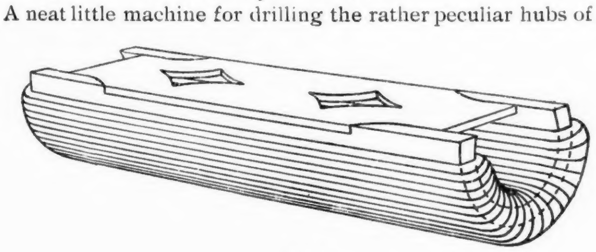


FIG 8.

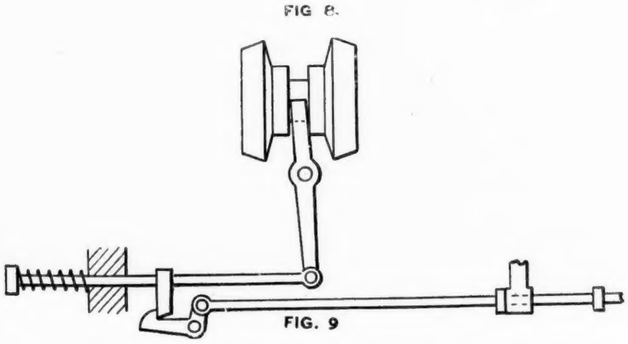


FIG. 9

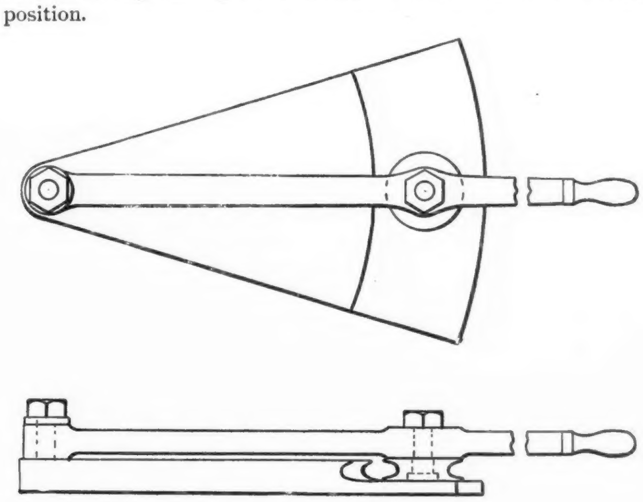


FIG. 11

Another little kink, which may or may not be new to many, is the shovel shown in Fig. 10, which looks as though it had been used for a target by a good rifleman; in reality the holes are drilled, and it is used to shovel the chips from the screw machines out of the iron pans beneath them. The perforations allow the oil, which is generally present in large quantities, to drain through, leaving the chips comparatively dry.

The front forks are bent by the device in Fig. 11, which is not

new, but which may be applicable to other work. The base plate is cast iron, with the groove fitting the section of the forks. The lever carries the roll, and the whole being mounted on a bench, is very convenient for any work of this character.

The work done here is of the highest character, and the wheels themselves are particularly strong, surprisingly so when their extreme lightness is considered. All material is thoroughly tested and the plant bears evidence of having a good mechanic in charge.

* * *

THE INERTIA GOVERNOR.

J. Begtrup.

To make use of the inertia of more or less ponderous masses for the purpose of increasing the efficiency of engine governors is not a very recent invention; but it is only in later years that the "inertia governor" has attracted the attention of the engineering profession, and a somewhat condensed explanation of the underlying principles and practical working of this class of governors will probably now be found interesting, coming from one who has devoted considerable time to the study of governors, and in a number of years has been identified with the manufacture of inertia governors as designer and experimenter. I shall not here attempt to use absolutely correct scientific language, which sometimes would involve explanatory matter of less importance; my sole object shall be to make my subject clear to the reader.

The inertia of a body means an inherent tendency to resist a change of motion, and as the motion may change in respect to velocity and also in respect to direction, we have two distinct forms of inertia. The inherent resistance to a change in *velocity* of motion may be called direct inertia or simply inertia, while the resistance to a change in the *direction* of motion is called centrifugal force. A revolving body as a governor weight being restrained to move in a circle is continually changing its direction of motion, and is therefore continually exerting centrifugal force on the restraining member of the governor. The amount of centrifugal force depends on the radius and velocity of motion; if the velocity is increased the centrifugal force will also be increased, being proportioned to the square of the velocity. The force that compels a body to move in a circle may appropriately be called a centripetal force, being equal and opposite to the centrifugal force. In a shaft governor for instance, the spring exerts a centripetal force on the fly-weight or ball. At the regular or normal speed the centrifugal and centripetal force balance each other, but when a change in speed takes place the centrifugal force will either increase or decrease, and the weight will move away from or toward the center of the governor under the action of unbalanced centrifugal or centripetal force. For a comparatively small change in speed as occurs in governors, this unbalanced force will be directly proportional to the change in velocity. Suppose part of the load on the engine is suddenly thrown off, then the speed will increase, but not suddenly, for the inertia of the fly-wheel and other revolving parts will prevent an instantaneous change of speed; the increase in velocity will be gradual as will also the increase in centrifugal force, and when this force has increased sufficiently to overcome the friction of the governor, it will commence to act. I shall in the following use the term "centrifugal governor" for governors actuated solely by centrifugal force.

The other form of inertia, which I have designated by direct inertia, can also be made useful in governors, for if a heavy weight be so pivoted to the governor as to allow some motion in the same or opposite direction into which the governor is moving, then the inertia of such weight will cause it to lag behind or move ahead of the governor when an increase or diminution of speed occurs; and this relative motion can obviously, by proper connections, be made to assist in the operation of the governor mechanism. If such mass or "weight" be added to a centrifugal governor, we have a combined centrifugal and inertia governor. The centrifugal part of the governor cannot be dispensed with, for it has a controlling power, never allowing the mean speed of the engine to vary beyond certain fixed limits, while the inertia governor is active when a change of load occurs, and otherwise is a most efficient auxiliary to the centrifugal governor, as will be fully explained.

We have seen that the centrifugal governor does not act promptly, because when the amount of load on the engine is varied, no unbalanced centrifugal force is immediately available to make the governor operative; first after the speed of the governor has changed to some extent will the unbalanced centrifugal force have increased sufficiently to have any sensible effect on the governor; but with the inertia governor it is different—the force or reaction of the inertia weight is greatest the very moment a change of load occurs, because at that moment the *acceleration* of speed is greatest. Speed or velocity is the rate of motion in respect to time, as when a governor is known to make 100 revolutions per minute the speed is given. The acceleration is the rate at which the speed is *increasing* on account of an unbalanced force. When the steam pressure in the cylinder is greater than required for the work the engine is doing, the speed of the governor will be accelerated. The acceleration is proportional to the accelerating force and will therefore be greatest the moment some load is thrown off; for after the governor commences to act, the mean steam pressure in the cylinder will be reduced; and as conversely the force of the inertia governor is proportional to the acceleration, the action of this governor will be most powerful the moment a change of load takes place; in this respect it has a decided advantage over the centrifugal governor. It should be remembered that if the acceleration is constant during a short period, centrifugal force will be uniformly increasing while the force due to direct inertia will be constant during that period. An example from theoretical mechanics will give the reader an idea of the different results obtainable with both forms of governors. Let a ball which weighs 48 pounds and is free to move be acted upon by a constant force of one pound: if this ball starts from rest it will have moved 4 inches at the end of one second; but let the impelling force commence with nothing and gradually increase to two pounds at the end of one second, then the ball will only be moved $\frac{2}{3}\times4=2\frac{2}{3}$ inches. Let the force be two pounds to start with and gradually diminish to nothing at the end of one second, then the ball will be moved $\frac{4}{3}\times4=5\frac{1}{3}$ inches in that period, still the velocity of the ball at the end of one second will in each case be 8 inches per second, so although the motion is quickest by the gradually diminishing force, the ball does not in that case acquire any greater momentum than in the two other cases. This latter case represents approximately the action of an inertia governor and shows at least that the inertia governor ought to give the best results. But it will also be readily seen that if the governor is so designed as to make the relative motion of the inertia weight proportionately great, it may delay the action instead of accelerating it.

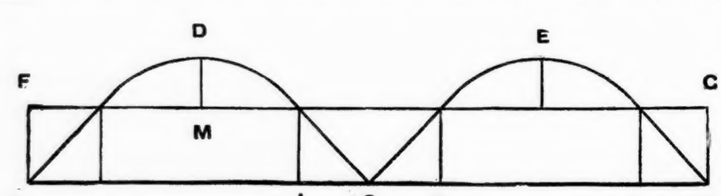


FIG. 1

The inertia mass or weight may be in the form of a wheel or ring loosely mounted on the engine shaft, and may then properly be called an inertia or momentum wheel, or it may be a heavy body of various shape mounted on a pivot on the governor wheel or carrier, and may be called an inertia weight. By weight is here understood anything heavy of considerable size or weight. Weight is, according to Webster, a correct expression for "a ponderous mass, something heavy," and the term inertia weight should not be supposed to imply that the weight of the mass

must have anything to do with its action, for an inertia-weight would be just as effective if it had no weight. The term inertia weight has been criticized, but I think it is the best that can be found, and it is not incorrect. The fly-weight or ball, which acts by centrifugal force, may appropriately be called a centrifugal weight in contradistinction to an inertia weight.

From what has been said, it will appear that if the engine is suddenly relieved of a considerable part of its load, or more load is suddenly added, the effect of the inertia weight will be to immediately overcome the friction of the governor journals and valve gear, which always tends to impede the action of the centrifugal governor more or less; but the inertia weight, if properly designed, will also increase the sensitiveness of the governor, and insure great promptness of action by exceedingly small variations in load or steam pressure. This is due to another property of the inertia governor, which should not be overlooked. It is well understood that during each revolution of the crank, the driving effect varies considerably according to the position of the crank, and being reduced to nothing twice during each revolution when the crank is in line with the connecting-rod, it gives rise to minute periodic fluctuations in speed. The actual variation in speed is hardly ever discoverable on account of the short periods or great frequency of the fluctuations; but the variation in accelerating forces is quite considerable, and the inertia weight being susceptible of this, becomes very sensitive to such fluctuations, and unless the friction is considerable and the fly-wheel very heavy, it will respond to the periodic acceleration and retardation and keep the governor mechanism in a condition of constant vibration. The effect of this will be to eliminate the effect of friction of rest and thus allow the governor to yield to the slightest increase or decrease of centrifugal force.

That these governors when properly designed and constructed are exceedingly sensitive to very small variations in load and steam pressure has been proven by a great number of experiments, but it can readily be seen from the above reasoning that it must be so. It has been argued that the vibrations here referred to might, when light fly-wheels are used, become excessive and interfere with the proper action of the governor. This may seem a natural inference, but the conclusion is nevertheless wrong; in fact, an inertia governor can be used and give good results with a much lighter fly-wheel than would be acceptable if the ordinary centrifugal governor was used. One reason for this is that with the lighter fly-wheel the influence of acceleration becomes more marked and the inertia weight consequently more effective. The relative motion of the inertia weight due to periodic acceleration and retardation, will also be regularly periodical, and can therefore have no influence on the steam distribution or cut-off. It has been suggested th .t the extent of these vibrations might be quite considerable, but I hope to be able to show here that this is a mistaken notion, that they are always under all conditions which occur in practice, quite inconsiderable compared with the greatest displacement of the inertia weight under extreme variations in load.

In Fig. 1 let the straight line $a\ b$ represent the developed path of the crank during one revolution, with the "dead centers" at a o and b, and let ordinates to the curved lines $a\ d\ o$ and $o\ e\ b$ represesent the varying rotative effect, also let ordinates to the parallel line $f\ g$ represent the resistance or load on the engine, then evidently $h\ i$ and $k\ l$ represent two periods of acceleration, and $a\ h+l\ b$ and $i\ k$ two periods of retardation; $d\ m$ represents the greatest accelerating effort and $a\ f$ the greatest retarding effort. The average length of the periods is one-quarter of a revolution, not one-half revolution, as is sometimes erroneously assumed. Now it should be remembered that the displacement of the inertia weight is proportional to the square of the period or time of acceleration and retardation, just as the displacement of a body under the action of a constant force, as, for instance, gravity, is proportional to the square of the time. The displacement of the inertia weight in one-quarter of a revolution will therefore only be one-sixteenth of what it would be if the period had extended over one entire revolution. Next it should be noticed that the acceleration or retardation of one period increases gradually from nothing and then again decreases to nothing, which makes it only half as effective as if the acceleration had been uniform and equal to the maximum represented by the line $a\ f$ and $d\ m$. For these reasons the displacement of the inertia weight due to such periodic acceleration and retardation cannot be more than one twenty-first of the displacement during one revolution, when all the load is suddenly thrown on or off the engine. It will in fact be considerable less than this, for the inertia weight is not independent of the rest of the governor; it must yield to some extent to the action of friction and also to the inertia of other parts which acts in opposition to or reacts on it. When, therefore, the speed of the governor is accelerated or retarded, the speed of the inertia weight will also be accelerated or retarded, although to a less extent. This circumstance reduçes the oscillation considerably, for every time the direction of an effort is changed, the inertia weight has acquired or lost some velocity, and it must be brought to rest relatively to the governor before any displacement in the opposite direction can take place—it follows the general law of oscillation. It will therefore be easily comprehended that such oscillation of the inertia weight cannot have any disturbing effect. Numerous experiments with very light fly-wheels have established this as a fact beyond question.

It will readily be admitted that what has here been said about the inertia governor refers to points of real merit, but there are other points of no less consequence which shall be explained in a subsequent issue. I shall there explain why it is possible to obtain a degree of stability in the inertia governor which cannot obtain in a centrifugal governor, the oscillating motion of the governor weights will be considered and the cause of "racing" explained.

* * *

THE WAGE QUESTION.

I have read with interest the articles on piece-work by 'Been There' and *Master and Man* by 'Missing Link,' in MACHINERY and would like to see such articles continued, as good may come out of them. The average mechanic who wishes to have his pay raised has quite a job on his hands, as I know from experience. It seems as though the increase in his wages is about the square root of the increase in amount of his work.

"Missing Link" apparently does not believe in labor unions A good many, especially among the employers of labor, will probably agree with him in this particular. A certain manufacturer (a friend of mine), in speaking of labor unions, once said: "The trouble with labor unions is that they would have all the workmen receive the same wages; now there is a great difference in men. I have some working for me on the same work who are worth just twice as much as others." Upon being asked if there is twice the wages paid to the most efficient, he replied that "There is not;" that he gave the ones that did the most about 10 per cent. more wages. This goes to prove that in this instance the men who did the most work did not get what they should, or that those who got the least wages got too much; but the latter is not likely in this age of competition. I do not imagine that things would be much worse for either the "master" or "man" if labor was organized into an immense labor union. Under the present system, as is well known, a working mechanic can receive just so much and no more, and that is just enough to live on for himself and family in prosperous times. If he is to get more he must become something else besides a workmen.

I believe it is commendable for a workman to have ambition to advance himself all he can, and when he reaches the top he should still have some sympathy left for those who are left behind in the race. The great majority, however, must remain workmen. Now, can there be no bettering of their condition except as they rise above the average in ability? In this age of progress, fortunes have been made through machinery which were impossible a few generations ago, and the mechanic still obtains little more than a bare living.

Perhaps it is the mechanics' fault. If he can be hired to work for small wages, that is all he will get, and that is the market price for his labor. I judge there are mechanics of average ability and also those of more than the average, who from circumstances beyond their control do not get a chance to rise, and while it is essential for them to read and study about their business, to take an interest in mechanical literature, etc., yet if mechanics are ever to better their condition to any great extent they must study something else also. Now I would like to have some of the readers of MACHINERY propose a remedy (for the benefit of mechanics) from the existing condition of things, not as much for the benefit of a mechanic as an individual, but for mechanics as a whole. The better the condition of the mechanic, the better it is for the prosperity of his country, as is proved in the book of Lujo Brentano, on "Hours, Wages and Production." J. T. G.

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NOVEMBER, 1895.

The total receipts from subscriptions to MACHINERY during last September were within a few dollars of five times the amount for the corresponding month of 1894.

* * *

MANY readers do not realize that a monthly paper must be made up and on the press a week or ten days before the date of issue. As an example of this we receive on the 24th of the month a request to insert a certain article, which is then unwritten, in the next number of the paper. The notice above, regarding the receipt of copy by the 10th of the month, is evidently overlooked or considered as a joke.

* * *

WE publish in this issue an illustrated article on the various types of milling machines, which we expect to follow with similar articles on other well known machines in every day use. Believing that a comparison of the leading tools of different makes will help to familiarize mechanics with the prevailing designs in milling machines, with the characteristic details of different makes, and with their adaptability to different kinds of work, we present such details as are available at this writing. If any important details are lacking, it is because the manufacturer has failed to supply them.

* * *

A GOOD WAY TO LOSE TRADE.

The late dullness in the machine trade caused many manufacturers to look around for other lines of work than those to which they had been accustomed, and the phenomenal increase in the production of bicycles gave them a chance to devote their energy to building machinery for their manufacture on a large scale and at low cost. This enabled more than one machine builder to keep afloat during the dull times in his own line of machinery, and the opportunity was one not to be despised. In the meantime the lines of trade which they had established by years of hard and persistent work began to improve, but finding the entire attention of their former tool builders given to bicycle machinery it was an easy matter for the enterprising salesmen of smaller concerns to secure a trial order for their machines, and as in many cases the difference in machines is as much a matter of name plates as of anything else, the machines of the smaller firms gave satisfaction and more were ordered, securing a trade for the small concern which, though not large, is assured as long as they attend strictly to business in their line. This is no fairy story of a possible occurrence, but has been done and is being continued at this writing.

The bicycle trade was a very timely and legitimate means for tiding over a dull season in machine building circles, but it should not be allowed to divert careful attention from established lines of trade which are likely to be more enduring than the present extensive building of bicycles by so many concerns. Franklin has been credited with saying: "Don't put all your eggs in one basket," but the writer agrees with Mr. Clement Hoopes who said: "Put all your eggs in one basket *and watch the basket.*" In other words, stick to your special line of work as long as there is anything worth sticking to, and if necessary to add other business see that it does not interfere with the regular lines of work, as old customers are lost much more easily than they were obtained, or can be regained if lost. It is simply one phase of the ever increasing specialism which cannot be ignored with impunity.

* * *

MODERN MILLING MACHINES.

The introduction of the milling machine into machine shop work has produced a variety of designs for doing the same work, and, like most other work, is now being divided into classes with special machines for each instead of attempting to do all kinds on one machine as formerly.

It was this which probably gave the name "Universal" to those machines which are now so common and so highly prized for tool room work, but which must give way to special forms for different classes of work, when the maximum production is desired.

It is a delicate matter to know which machine to mention first, as it is perhaps difficult to tell which were first on the market, so the safest way out of it is to follow the alphabetical arrangement and the BECKER machine comes to the front, although newer than some of the others. This is a vertical machine, which in its latest forms has about all the universal features of the others, as far as variety of work goes and has some virtues which are perhaps not well understood but which are inherent in a properly designed vertical machine.

The permanent alignment of the spindle, an all-important feature in a machine of this type, is secured in a very ingenious manner by a neat device, the details of which we were unable to obtain in time for this issue. This feature is perhaps the

greatest aid toward making the machine a success.

Those who are not familiar with the merits of a machine of this type will be surprised to learn its capacity for such work as surfacing, milling circular slots or the whole interior or exterior of a ring locating and boring holes an exact distance apart, profiling, slotting and many other operations in which its large field of usefulness becomes more apparent as it is used. As will be seen, it is well designed and has generous bearings; the spindle being 3 inches in diameter and capable of running from 10 to 800 revolutions per minute, a range which is necessary for a large variety of work.

This machine is powerfully back-geared. The main bearing is provided with a ball thrust bearing at both ends. The head has a vertical movement of 7 inches and is provided with automatic stop, which can be set to 1000ths of an inch. The knee has a vertical movement of 18 inches and a rotary attachment on table makes a large variety of work possible.

The BOGERT machine is of an altogether different type. It is constructed either with a head-stock on one column and a foot-block on the other, or with head-stocks on both columns. It is interesting to note the fact that many years ago a valve milling machine was introduced to the mechanical public by a celebrated

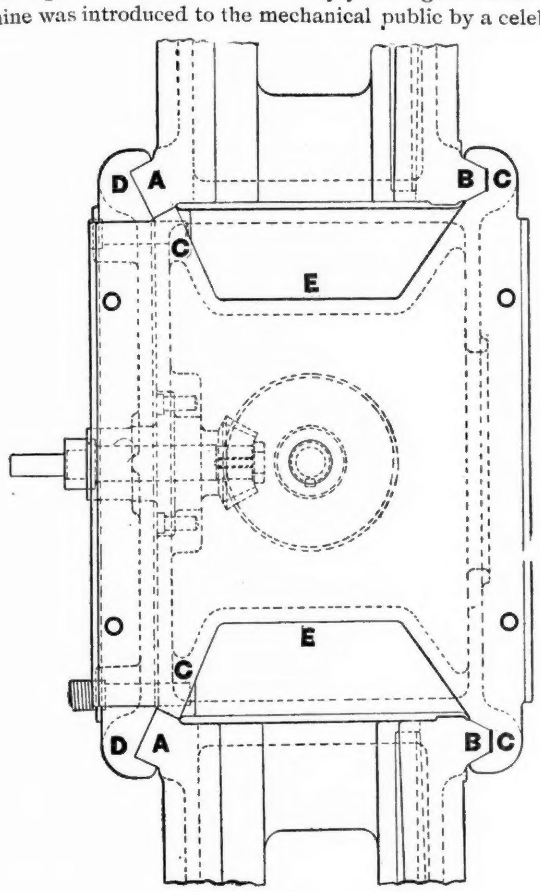


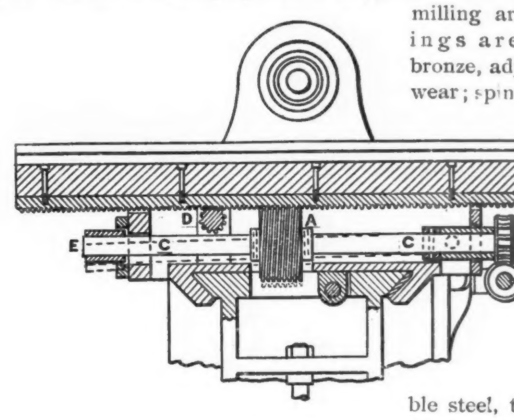
FIG. 1.

brass tool-making concern, that contained the germ of this design. It was not till the year 1883, however, that Mr. John. J. Grant, then associated with Mr. Bogert, made the drawings for a double-column machine. Since then it has grown into its present distinctive shape, at the hands of Mr. Bogert alone.

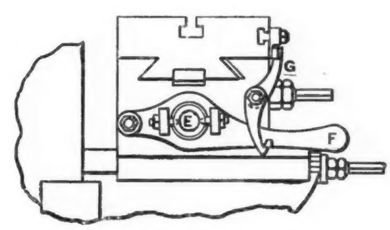
The general design denotes rigidity and the position of the table between the two supports insures a steadiness which is too often lacking in machinery of various kinds. The columns are of course, hollow, affording a convenient place for tools and mills. The spindles are of large dimensions; the other details having been given in our September issue, need not be repeated.

The main feature is perhaps the design of the saddle, a plan view of which is shown in Fig. 1. This is the outcome of years of experience, and is worthy of a closer study. The main body of the saddle extends clear through the machine, as shown at C C C C. This bears full at B B and on one surface of A A, as shown, which not only gives a solid bearing, but also allows the saddle to be scraped to a bearing and to perfect alignment, which is a feature of no small importance in practice. The clamping plate D D is fastened by through bolts and can be locked solidly at any point, or readily released sufficiently to be moved vertically with a good working fit. This design is said to have solved the problem of a practical saddle for the machine, remedying defects of construction contained in the older forms. To outward appearances the cones of this machine are overhung, but this is not the case, the bearing being extended far enough inside of them to insure rigidity and avoid that bugbear of machinery, overhanging pulleys. The recesses E E allow the saddle to be raised a short distance past the bottom of the heads, a very handy feature many times.

The BRAINARD machine shown is one of the heavy universal type, with the overhanging arm to support the outer end of the milling arbor. Bearings are of hard bronze, adjustable for wear; spindle of cruci-



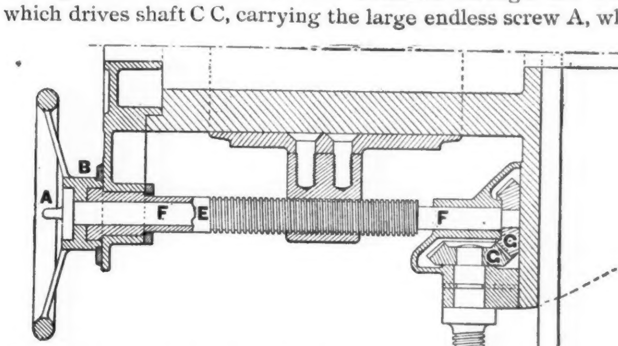
ble steel, threaded to receive chuck with a cap to protect thread when not in use. It has a long range of feed, will carry an 8 inch cutter and is driven by a $2\frac{3}{4}$ inch belt. This machine is adapted for the various operations re-



FIGS. 2 AND 3.

quired in the tool-room and for the large variety of work which gave rise to the universal machine, such as gear and rack cutting; cam and spiral cutting, and to receive a number of attachments for other kinds of work. The designer of this machine is one of the pioneers in milling machines and milling machine work, and there are many points which will interest the careful observer.

One important feature is the feeding device which we illustrate in Figs. 2 and 3. The feed is obtained through the worm, which drives shaft C C, carrying the large endless screw A, which



drives the table by rack B. Fig. 3 shows the lever on end of shaft at E which carries that end of shaft by pivots shown. The endless screw is held to position by latch G holding lever F in position shown. When the latch is tripped by stop on table the lever drops and carries screw out of rack, stopping feed. Table can be returned rapidly by hand with pinion D, or quickly moved to any position. The screw feed is a very desirable feature as it gives a remarkably smooth and steady cut, and when used in this way has none of the objections of slow handling which is sometimes charged against it.

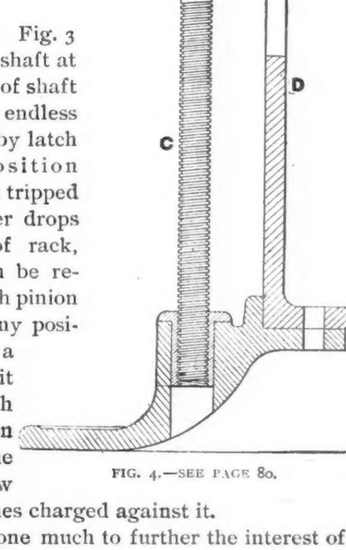


FIG. 4.—SEE PAGE 80.

BROWN & SHARPE have done much to further the interest of the milling machine, and the large numbers that have been made have afforded an excellent opportunity to find just what was

needed in this line of machines, the product of 1895 embodying the changes which have been deemed necessary. This is one of their heaviest machines and one which is capable of doing about as heavy work as any universal machine ought to do. When it comes to much heavier work it is about time to get a special machine adapted to it. The knee, which is an all important portion of the machine, is very rigid, and has a movement of 18½ inches vertically. The saddle, which carries the table, pivots in the clamp bed and is held rigidly to it by three bolts, at any angle up to 45 degrees, each way, from zero. Fixed handles are used for clamping, doing away with either losing or chaining wrenches.

Feeds vary from .003 inches to .22 inches to one revolution of spindle, which gives about all the variety needed when they can be used without regard to the speed of the mill. The cones are designed for 3½ inch belts, which will give an idea of the power of the machine. The net weight is about 2,860 pounds.

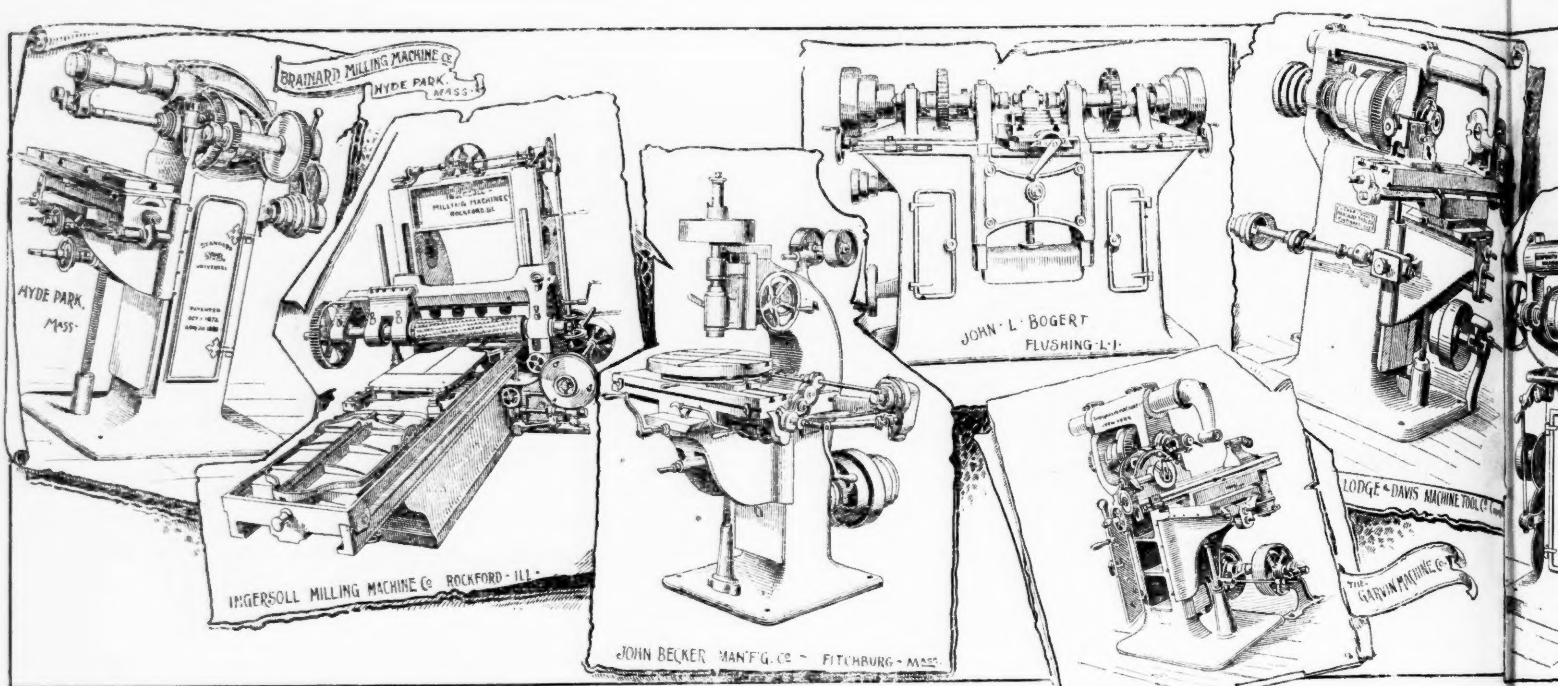
Owing to the makers being extremely busy we were unable to obtain the desired details of this machine. A good general idea can, however, be obtained from the outline sketch.

The CINCINNATI milling machine is not essentially different in general appearance from others of its type, yet each has peculiarities of its own which are probably due to different conditions which existed when it was designed and each is, of course, the best—as is usual with any line of manufactures.

inches in diameter, while the spindle bearings are 3x5 inches and 2½x 4 inches respectively. It seems rather strange that this type of column should not have been put on the market before, as it is an old machine shop maxim that a round surface or bearing is the easiest to produce, although improved machinery may have modified this somewhat.

The machine is so rigid in appearance as well as at work, that one is apt to expect too much of it, as instead of being a machine for extra heavy work, the one shown is only for such work as should be done on a plain miller of its size, there being no back gear, although these will be made as soon as possible. The table feed is derived from the disc at the back, and as the disc is *driven* instead of being the driver, the slowest feed is obtained with the friction at the outer edge of the disc where the leverage, and consequently the power, is at the maximum, giving the most power when it is needed.

The knee is raised by hand in this machine, the vertical power feed not being found necessary after a thorough trial. Fig. 4 shows both the raising screw and the one which gives the transverse motion to the table. D is the main column of machine, A the hand-wheel, F a shaft (with a flange at the left in wheel), which is independent of the screw E, and controls, by the bevel gears G G, the vertical screw C. The screw E controls the transverse motion and is entirely independent of the vertical screw



This is another of the universal type of tool-room machines which are fast becoming indispensable. We were unable to obtain details, and can only give a few of the general points. Adjusting and operating devices are very convenient, and as all screws have large dials the micrometer reading is very easily accomplished. A wide range of feeds is provided, and by a simple mechanism at back, twelve uniform changes can be had for each speed of spindle. This has a circular swiveling carriage for table, which is convenient and allows the carriage nearer the column when set at an angle, and can be completely revolved. The dividing head is completely universal, as the swiveling block (carrying spindle) makes a complete revolution. Right and left-hand work can be cut with the same cutter. There are several other features of interest in connection with this head which require detailed drawings to illustrate. The feed varies from .006 to .150 inches per revolution of spindle; driving belt, 3 inches; vertical adjustment, 19 inches; weight of machine, 2,800 pounds.

In the FORBES machine we have a distinct type of design, the cylindrical form being used for the principal bearing surfaces, as will be seen. This is at once unique and sensible, as it is not an expensive form to produce, and when the moving portion is clamped to its place it is extremely rigid, a very desirable and necessary feature in doing nice work. The main column is 16¾ inches in diameter, the bearing for the transverse motion 8

The hand-wheel A is independent of both screws, but is locked with either by an ingenious little locking-bolt at B (not shown). In its central position it can be turned without moving either screw. Moving it toward the column locks it with the screw E and gives the transverse motion. Locking in the outward position controls the vertical motion through shaft F.

The GARVIN machine is another of the heavy universal machines whose capacity for work can be judged from the fact that a 5 inch belt is used for driving. The main spindle bearings are 5x6¼ inches, the bearing of table in swivel block 25 inches, with other bearings and lengths of feeds in proportion; twelve changes of feed being available as in the Cincinnati machine. Details could not be obtained in time. The net weight is about 5,200 pounds.

The INGERSOLL machine represents a special type designed for that class of work which comes under the head of surfacing, although this must not be construed to mean only the production of plain flat surfaces.

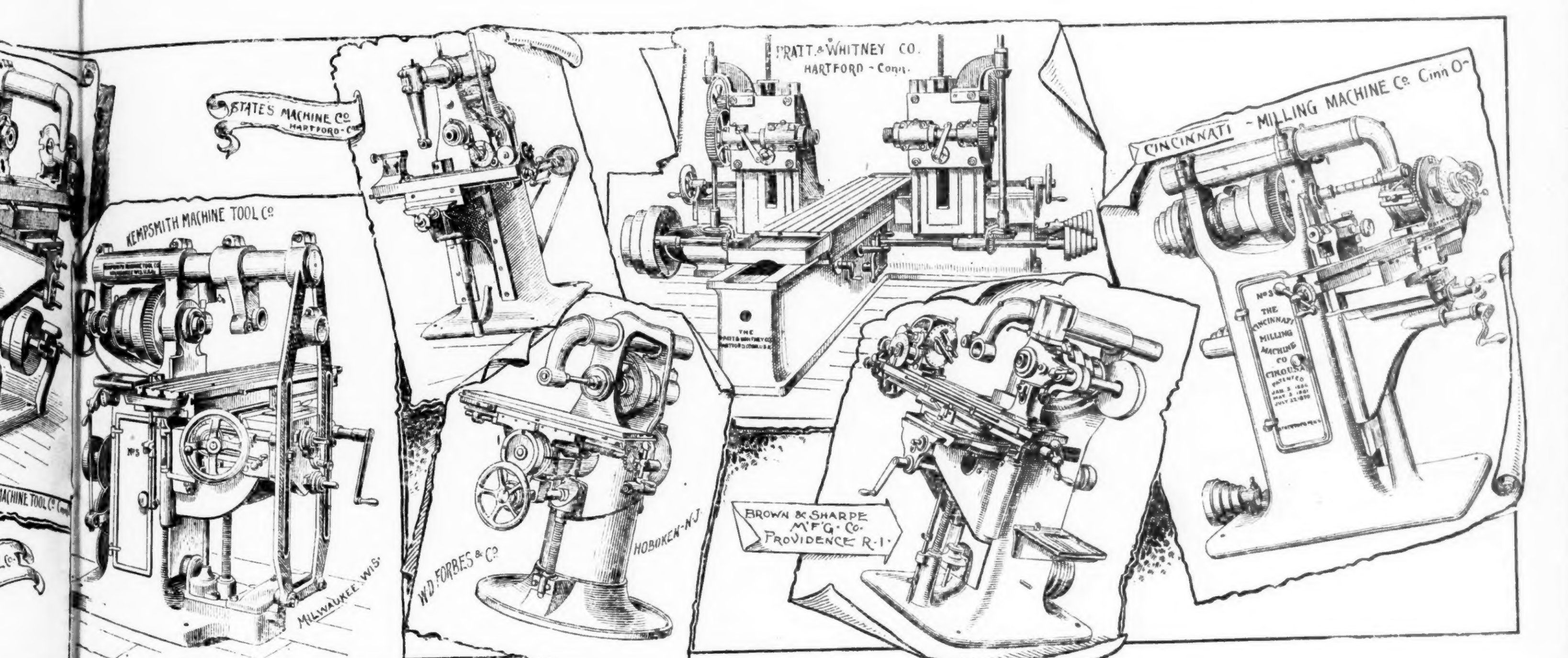
This type of machine is an application of the milling cutter to a planer bed, having the single planer tool replaced by the many toothed mill, and the speed of movement of the bed and tool reversed. In this case the speed of tool can well represent the movement of the work and planer bed, while the cutting speed is obtained by revolving the tools (in this case the mill) fast enough to produce the required speed. This form of machine is well

adapted to the work for which it was designed, *i. e.*, heavy surface milling; overhanging arm to support the outer end of milling cutter being replaced by a rigid outer bearing head, a necessary feature for work of this size and weight. The Ingersoll milling cutters have attracted much attention and the general appearance can be seen from the cut. As each type of machine has its own field or fields, the student of the design and application of milling machines can find work especially adapted for this one.

Fig. 5 shows the solid construction of this machine. The angular cross-rail at H, with the parallelogram of forces A B C D, which shows how well this form resists the combined strains C B and C D. The arrows G F and T show the direction of motion of the different parts, and the solid construction indicates the heavy work of which it is capable. The plan view of the feeding mechanism shows the regular working friction feed at F, and the tight and loose pulleys at G which allow a quick shifting of the bed to any position. The table is moved by a Sellers screw on the shaft E through the medium of the gears D, the friction clutch at F is driven by a worm, which is in turn driven by a friction disc at the other end of shaft C, thus giving a great range of feed, from .8 inch to 4.6 inches per minute, in the 24×24 inch machine. Cutter speeds vary from 9¾ to 39½ revolutions per minute, there being eight changes. The bearings are large and well proportioned, with provisions for taking up wear, and the details are a stop on the bed. The feed is thrown in by moving rod F either right or left, as the direction of feed requires, until the projection on lever C is latched over the projection on latch A. Then the tripping of rod E forces down latch-pin D, which in turn forces down latch A, until the projection on C is released, and the springs throw it to the central position. This tripping box, if it can be so called, also controls the feed of the table on the knee in a very ingenious manner. The usual tripping handle in front of the table connects very simply with the finger G in such a manner (which cannot be shown, owing to limited space, but which can be readily understood by any mechanic) that tripping the handle in front of table also trips the feed in the same manner as before. This puts all the tripping devices in a small space and makes a very compact arrangement.

The Lodge & Davis machine is also of this type, with some peculiarities of its own, as all of them possess to a greater or less degree. It is solidly built and has ample weight and dimensions for the work to be done.

The frames are cast in one piece with the uprights, which are bored to receive spindle boxes and overhanging arm. Spindles are hollow, of crucible steel, and boxes are of phosphor-bronze. Feed can be reversed and tripped, automatically or by hand, in either direction, under full cut or running empty, and all tables have quick return. Feed screws are all indexed to 1000ths, as is



well worked out.

In the Kempsmith miller we have another of the usual column type, but heavier than many and capable of heavy work. The outer spindle support is worthy of notice, as it ties the overhanging arm and the spindle to the base of the machine and locking the knee at the same time, making a very rigid arrangement in this respect. The main spindle bearing is 3¾x5⅝ inches and it is driven by a 3½ inch belt, making a powerful machine. Feed changes can be had from .002 inches to .25 inches to one revolution of spindle, giving a little greater variation than the one mentioned previously. It has automatic feed and trip in six directions; feeds are all engaged by same handle and reversed by moving it in opposite direction. There are two sets of back gears which give 18 spindle speeds, twelve of which are in back gear. Ball bearings are used on elevating and feed screws. The machine weighs about 3,600 pounds.

The outline cut of this machine gives such a good idea of its general features that it is difficult to select any detail for special illustration. The little tripping device shown in Fig. 7 is, however, very ingenious and deserves attention. The latch A is in its normal position. The springs B B hold the lever C (which throws the feed gears in and out of mesh) in the middle position. The latch-pin D is shown in the recess in the tripping rod E, the end of which is pointed so as to trip the vertical feed by contact with customary in modern machines, and all feed screws can readily be adjusted for wear. The universal heads are particularly rigid and convenient. This machine carries a 3-inch belt, and has an overhanging arm 4½ inches in diameter. The table has 28-inches length feed, 7½ inches cross feed and 19 inches vertical adjustment of table.

Almost all makers of milling machines have their distinct features in regard to the feeding mechanism for their universal machines. In these machines the table must feed at any angle and at any position on the knee and column, and the mechanism employed is always more or less complicated.

While all get their impetus of feed from the rear end of the spindle and the variation of feed through cones, intermediate gearing, friction, discs, etc., some go with the connecting shaft through the center of the column to the inside of the knee, but the majority clear the column and connect from one side of the knee. To the latter class belongs the machine which feed mechanism is illustrated by the annexed sectional views.

The toggle-joint connects in the usual way with the rear feed cones of the machine. On the shaft of this bell slide feathered, is the double mitre gears *b b* engaging with mitre *c*. These mitres are shifted by knob *d*, and change the feed. The shaft *f* on mitre *c* with worm *g* is journaled in box *h*, pivotly held between lugs on the knee A. The worm engages the worm-wheel *j* fixed

on shaft *k*. Feathered on this shaft is the mitre gear *l*, carried in a bracket of saddle B. In the saddle is also journaled the vertical shaft *m*, which lower mitre *n* meshes with *l* and its upper O with mitre carried in a bracket of swivel slide C. The last named mitre transmits, by means of spline and feather motion to the table-feed screw, which has its fixed nut in swivel slide C.

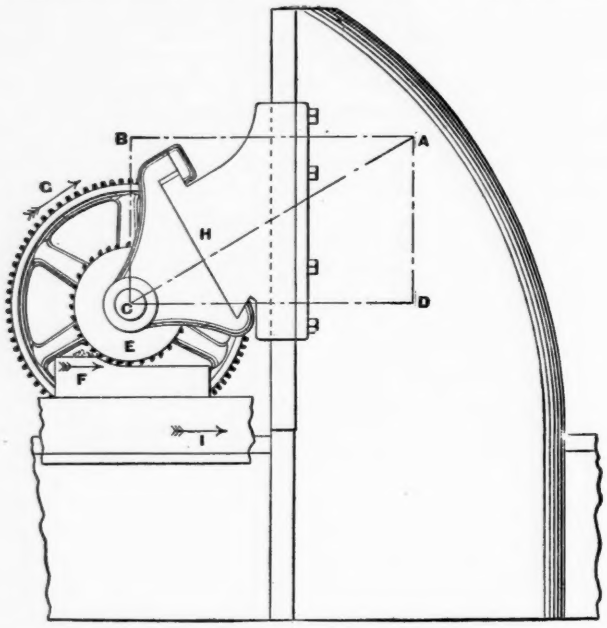


FIG. 5.—SEE PAGE 81.

The feed-tripping dog presses on top of the inclined plunger having on its lower end the fork D, semi-circling the collar I on mitre O; this collar rests on a plug bearing on bar F, connected with a tripping-hook and tripping handle.

The machine shown from the PRATT & WHITNEY Co. is a special machine of the planer type, with massive housings for holding and driving heavy cutters on the large class of work requiring them.

It is built with either one head and a foot-block or two heads as shown. The heads and parts which move vertically are all counterbalanced, clamped by T bolts and adjusted and fed by hand, either independently or together. The uprights can be

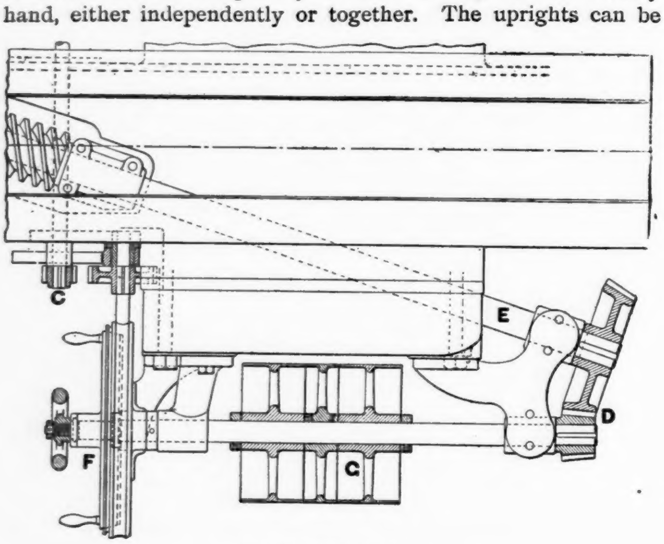


FIG. 6.—SEE PAGE 81.

adjusted toward or away from the table as required. Tables are made from 6 to 12 feet in length, and can be stopped automatically at any point with quick return. Six speeds and six feed changes are provided, the cone taking a 4½-inch belt and being back-geared with a ratio of 19½ to 1. The main bearing is 5½ by 11 in.; greatest distance between spindles, 54 in.; least, 14 in.; in.; greatest height of center above table, 25 in.; least, 4 in.

Speeds are made for cutters from 4½ to 18 inches in diameter. The weight, with 6 foot table, two cutters and countershaft is 23,000 pounds.

In the STATES MACHINE Co. miller we have a combination machine which consists of a milling machine proper provided with a telescoping spindle which forms the boring mill part of the arrangement. For a large class of work this is a very convenient and valuable machine, the boring feature being available for a much greater variety of work than seems probable at first sight.

The main spindle, which is very large, has lying inside of it and splined with it, another spindle of 2¼ inches diameter, bored to No. 5 Morse taper at the end. In milling, this spindle is simply a part of the main spindle. In boring or drilling, etc., the inside or telescoping spindle slides out of the main spindle, automatically or by hand feed, *into* the work set stationary on the bed or platen. The arm and the pendant are arranged for holding arbors in axial milling—for holding boring bars which slide through their bushings, close to the cutters, as a drill jig, etc. All the movable parts of the machines are graduated to .001 inch; the platen being universal, it will be seen that work placed on the platen can be milled, butt milled, bored, drilled, tapped, etc., in perfect alignment or at angles as wished, with one setting.

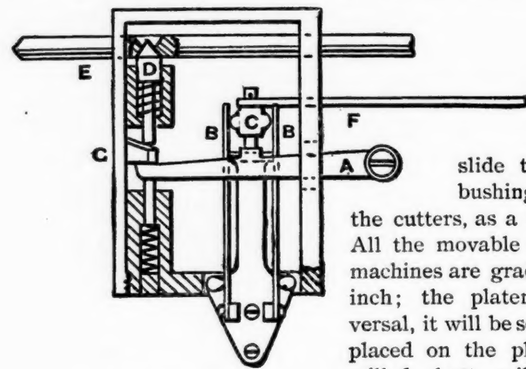


FIG. 7.—SEE PAGE 81.

The back gears lie inside of the frame, sliding separately on a feather. The back gear spindle carries the platen feed, which can be thrown in or off by sliding the gear in or out of mesh, without interfering with the back gear connections.

The knee is set on a very large screw at the center of the weight, which screw is stationary. The nut then revolves, doing away with the necessity of cutting holes in the floors.

The lift is by compound gears, making the raise with any weight very easy. All gibs are of the wedge pattern, and bear

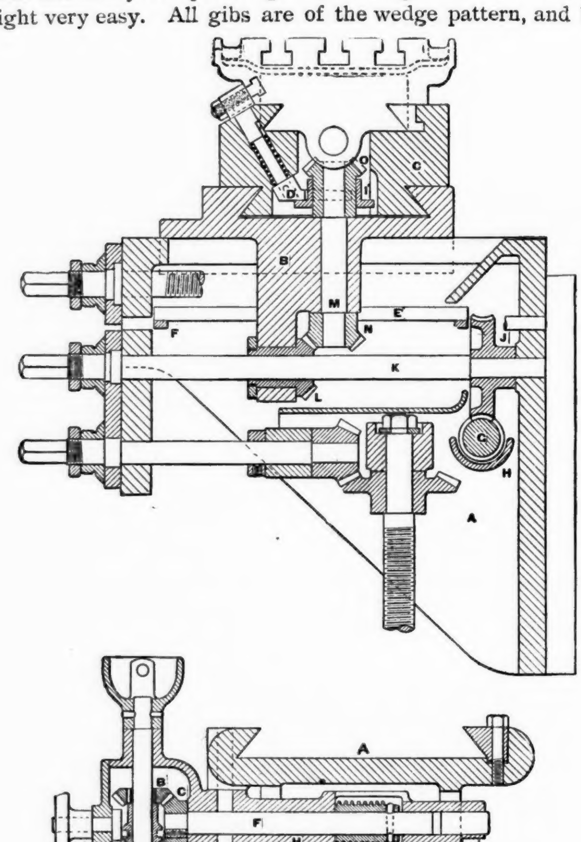


FIG. 8.—SEE PAGE 81.

the entire length of the bearing and not of the points of the screws. Particular attention has been given to the smaller parts and their quick and easy operation by the workman.

The Franklin Institute, when giving the John Scott medal, in their report said that "different from the usual results in this machine, one function of the combination no way interferes with the other, and the limit of capacity is in the strength of the cutting tools."

THE FIRST PRINCIPLES OF MECHANICS.—2.

LESTER G. FRENCH.

FRICTION.

Friction is the surface resistance which opposes the motion of one body upon another. It must be regarded as a force, although it is not always natural to think of it as such, for the reason, perhaps, that its action in resisting motion is of a negative character. The force of friction always acts in a direction parallel to the surfaces in contact. Thus, in Fig. 4, in pulling the block B along the surface, as shown, the frictional resistance is exerted in an opposite direction and parallel to the surfaces, as indicated by the arrow.

Friction should not be confounded with adhesion, which not only resists the motion of one body upon another, but tends to hold the two together so that they cannot be separated. Adhesion is independent of the pressure between the bodies, while friction increases with the pressure. Moreover, the smoother the rubbing surfaces the less the friction; two perfectly smooth surfaces, if such were possible, would be frictionless, while, as has been previously stated, the adhesion between them would be very great. Lubricants increase the adhesion and diminish the friction. When the pressure between two bodies is small, the adhesion forms a considerable part of the resistance, and as the pressure increases, it becomes proportionately less, since adhesion does not increase with the pressure. At ordinary pressures the effect of adhesion can generally be neglected, and the whole resistance considered as the friction.

KINDS OF FRICTION.

(*a*) A distinction is usually made between *friction of rest* and *friction of motion*, the former being the frictional resistance to be overcome in starting a body into motion, and the latter the resistance that continually accompanies the motion. Friction of rest is generally greater than friction of motion, other conditions being equal.

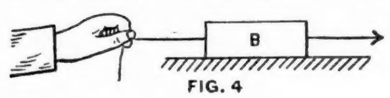


FIG. 4

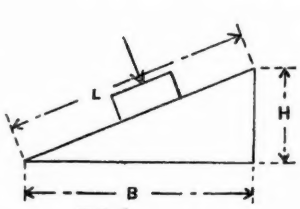


FIG. 5

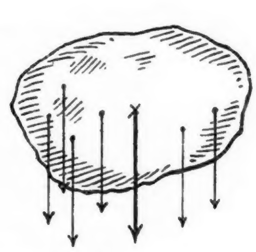


FIG. 6

(*b*) When friction is mentioned, *sliding friction* is understood, *i. e.*, such as that between an engine crosshead and its guides, or between a journal and its bearing. It is due to the roughness of the surfaces in contact. Whenever wheels are employed, or rollers or balls placed between the surfaces, the resistance is called *rolling friction*, the nature of which is somewhat different; it is then due to the fact that the rolling body makes a greater or less depression in the surface of the other, so that it has continually to rise out of a hollow, as it were.

(*c*) Frictional resistance also occurs between the molecules of liquids and gases, or between them and any solid body with which they may be in contact, as in the case of air when blown through a pipe, or a ship when sailing. This kind of resistance is called *fluid friction*. Its action is very different from that of the friction of solid bodies, and it is different in its nature.

LAWS OF FRICTION.

Certain conclusions have been drawn from early experiments upon friction, which are known as the laws of friction. They are only approximately true, however, and apply only within certain limits. Outside of those limits they have been proved by later experiments to vary, in some cases very widely. They are:

(1) Friction is proportional to the normal pressure between the surfaces.

(2) It is independent of the areas, or sizes, of the rubbing surfaces.

(3) It is independent of the velocity of motion, though friction of rest is greater than friction of motion.

In law 1, by "normal pressure" is meant the pressure in a direction at right angles to the surface. If an object rests upon a horizontal plane, like the top of a table, the normal pressure is equal to its weight. If it rests upon an inclined plane, as in Fig. 5, the normal pressure (in the direction of the arrow) is found by dividing the horizontal distance b by the length l of the plane, and multiplying the result by the weight W of the object, or

$$\text{Pressure} = \frac{b}{l} \times W \quad (4)$$

Law 1, therefore, means that for any increase or diminution of the perpendicular pressure, the friction varies in the same ratio; thus, if the pressure is doubled or tripled, the friction becomes twice or three times as great Law 3 varies most widely at high velocities, which tend to diminish the friction,

In order that these laws shall hold the velocity of motion of the sliding pieces must be comparatively slow, the surfaces must have little or no lubrication, and the normal pressure must be great enough so that the effect of adhesion will be inappreciable, but not so great as to cause the surfaces to "seize."

It is not intended to treat of fluid friction here, but it will be convenient to have the laws for comparison with those just given. The three most important laws are as follows:

(1) Fluid friction is independent of the pressure.

(2) It is proportional to the area of the rubbing surfaces.

(3) It is proportional to the square of the velocity at moderate and high speeds, and to the velocity, nearly, at low speed.

The friction of lubricated surfaces departs widely from any set of laws. Where the lubricant is very freely supplied, the friction depends upon the nature of the lubricant more than upon the material of the surfaces. As the surfaces become dry, the friction becomes like that of solid bodies; and when they are flooded with oil, it is more nearly like fluid friction.

COEFFICIENT OF FRICTION.

If it should require a force of 10 pounds to pull a wooden block weighing 20 pounds along the surface of a board, the frictional resistance would be ½ or .5 of the normal pressure Again, if a weight of 40 pounds were added to the block, making a total weight of 60 pounds, we know from law 1 that the resistance would be three times as great, or 30 pounds, which is still .5 of the pressure; and so, for any weight within the limit of law 1 the ratio of the friction to the pressure would remain this constant number .5. Knowing this, if it were desired to obtain the friction for any given weight of block, it would only be necessary to multiply the weight by .5, and if we had different numbers for different materials and various conditions, it would be very easy to calculate the friction for any particular case.

Any constant number like that above, which depends for its value upon the substance or conditions in question, is called *a coefficient* and in the present case *the coefficient of friction*, which may be defined as that fraction of the normal pressure which is required to overcome the friction between two surfaces. *It is found by dividing the force of friction by the normal pressure.* Or expressed as a formula,

Letting f = the coefficient of friction,
F = the force of friction,
and P = the normal pressure,

$$f = \frac{F}{P} \quad (5)$$

The following coefficients of frictions may be taken as average values where more complete tables are not at hand*. Under varying conditions a wide variation from these values may be found, and where coefficients are to be used, they should be obtained, if possible, from experiments suited to the particular case.

Wood on wood, dry	.4 to .6
Metals on metals, dry	.15 to .2
Metals on metals, lubricated	.03 to .08
Metals on wood, dry	.5 to .6
Leather on metals, dry	.3

If a body be placed on a plane surface, and the latter inclined until the body is just at the point of sliding down, the angle found by the plane with the horizontal at that instant is called the *angle of friction*, or the angle of repose. It can be shown that when the plane is at this point, its height divided by the base ($h \div b$ in

* Tables may be found in Wood's Elementary Mechanics and Kent's Mechanical Engineers' Pocket Book.

Fig. 5) is equal to the coefficient of friction. This fact affords one means of finding the coefficient of friction of materials by experiment. Written as a formula, we have, f being the coefficient of friction,

$$f = \frac{h}{b} \quad (6)$$

Example 1.—(*a*) What force would be required to slide a body weighing 20 pounds along a level surface, if the coefficient of friction is .6? (*b*) If a force of 30 pounds were just sufficient to move the body, what would it weigh, assuming the same coefficient?

In formula 5 there are three quantities, f, the coefficient of friction; P, the normal pressure, and F, the force of friction; but the formula is so written that it gives an expression for the value of one only, viz., the coefficient of friction. Very often a simple formula like this is met with from which, knowing the values of *any* two quantities, it is desired to find the value of the third. By the principles of algebra, formula 5 may be written

$$F = f \times P$$

$$\text{and } P = \frac{F}{f}$$

and by substituting the values given in example 1, the answers to the example, or values of F and P, can be easily obtained. For the benefit of those who have no knowledge of algebra, these transformations may be made clear, as follows: In formula 5, suppose $f=2$, $F=200$ and $P=100$; then by substituting, we should have the statements,

$$2 = \frac{200}{100}$$

It is evident, however, that, using the same numbers, either of the following statements:

$$200 = 2 \times 100 \text{ and } 100 = \frac{200}{2}$$

which, it will be seen, correspond to the second and third ways in which formula 5 is written above. It will be greatly to one's advantage to make himself so familiar with this point that he can at once write a formula containing three quantities in any one of the three different ways.

Now, solving Example 1, noting that the normal pressure is here equal to the weight of the body,

(*a*) $F = .6 \times 20 = 12$ pounds.

(*b*) $P = \frac{30}{.6} = 50$ pounds.

Example 2.—If a body just slides by its own weight down an inclined plane 15 feet long, and which has a rise of 9 feet, what is the coefficient of friction?

In order to apply formula 6, we must find the length b of the base of the plane.

Base $= \sqrt{15^2 - 9^2} = \sqrt{225 - 81} = 12$ feet.

From formula 6,

$$f = \frac{9}{12} = .75$$

Example 3.—Find the work required to draw a weight of 150 pounds up the incline of example 2, the coefficient of friction being .08.

Divide the problem into two parts, first disregarding friction (see (*c*), under the *Measurement of Work*, October number), and then compute the work done against friction.

Neglecting friction, work $= 150 \times 9 = 1350$ foot-pounds.

From (4), normal pressure $= \frac{12}{15} \times 150 = 120$ pounds.

Hence, friction $= 120 \times .08 = 9.6$ pounds.

Work against friction $= 9.6 \times 15 = 144$ foot-pounds.

Total work $= 1350 + 144 = 1494$ foot-pounds.

It will be noticed that in the solution we first divided and then multiplied by the length l of the plane, so that this number cancels, and the same answer would have been obtained directly if we had multiplied the length of the base, the weight and the coefficient of friction together. Thus,

Work against friction $= 12 \times 150 \times .08 = 144$ foot-pounds.

Hence, the work done against friction in moving a body from one end to the other of an inclined plane is the same as that required to move it along the base of the plane, under the same conditions.

EXERCISE 2.

1. (*a*) A force of 16 pounds is required to move a body weighing 96 pounds along a horizontal surface. What is the coefficient of friction? (*b*) If the coefficient of friction between two iron plates is .07 and the pressure between them is 50 pounds, what force would be necessary to slide one over the other?

2. Find by construction the angle of friction corresponding to a coefficient of .35.

3. A smooth incline is 30 feet long and the total vertical rise is 18 inches. How much work is performed in drawing a weight of 1000 pounds one-third of the way up the incline? Coefficient of friction = .14.

3. Suppose a body resting upon an inclined surface to be just at the point of sliding. (*a*) If the coefficient of friction is .42 and the height of the surface is one foot, what is its length? (*b*) If the base is 20 inches what is the height, assuming the same coefficient?

ANSWERS TO THE EXERCISE IN THE OCTOBER NUMBER.

1, (*a*) 312,500,000 foot-pounds. (*b*) 315,66, nearly, H. P.

2. Multiply the man's weight in pounds by the vertical height in feet of the stair-case.

3, (*a*) The resistance $= 20 \times 100 = 2,000$ pounds and it is moved through $\frac{5}{8}$ of a mile. Answer. 8,800,000 foot-pounds. (*b*) $266\frac{2}{3}$ H. P.

4. 18,750 foot-pounds.

5. 12.12 H. P.

6. $\text{H. P.} = \frac{2\,\text{PLAN}}{33,000} = \frac{2 \times 40 \times 2 \times 153.94 \times 90}{33,000} = 67.18$, nearly.

7. The pressure of the burning gases acts upon the piston every fourth stroke; hence, divide the number of revolutions by 2 instead of multiplying by 2. Answer, 23.8 H. P.

GRAVITY.

The attractive force that exists between the earth and all bodies at or near its surface is called *gravity**. Weight is due to gravity. A body has weight because it is pulled downward by the force of gravity, and the amount that it weighs is a measure of this pull. A piece of iron, for example, weighs one pound when it is of such a size and density that it is drawn to the earth by a force equal to that which attracts a standard pound weight.

As has been previously mentioned, the weight of a body (that is, the force by which it is attracted to the earth), varies slightly with the locality.

(*a*) Weight varies with the altitude. A body weighs the most at the surface of the earth, as the attraction is there the strongest. *Below the surface its weight decreases in the same ratio that its distance from the center of the earth decreases.* Thus, calling the radius of the earth 4,000 miles, the relative weights of a body at the surface and at one mile below the surface would be as 4,000 : 3.999; or at the latter point its weight would have diminished $\frac{1}{4000}$ part. *Above the surface, weight decreases in the same ratio that the square of the distance from the center increases.* That is to say, if a body be carried from the surface to the top of a mountain one mile high, the relative weights in the two positions would be as $4.001^2 : 4,000^2$, or as 16,008,001 : 16,000,000. Its weight would therefore diminish about 8,000 parts in 16,000,000, or $\frac{1}{2000}$ part.

(*b*) Weight varies with the latitude, or distance north and south of the equator. In passing from the equator to either pole, the attraction of gravity increases by $\frac{1}{568}$ of its original amount. This is due to the want of sphericity of the earth, the polar diameter being 26 miles shorter than the diameter at the equator. At the poles, however, a body would actually weigh more than this, or nearly $\frac{1}{192}$ more than at the equator. The difference, $\frac{1}{289}$, is due to the rotation of the earth on its axis, the effect of which is to produce a force directly opposite to that of gravity, (centrifugal force), which is greatest at the equator and diminishes in moving from it, until at the poles it becomes nothing.

HOW GRAVITY ACTS.

Under the influence of gravity all bodies tend to move in a direction toward the earth's center, or to "fall," as we say, our idea of "down" being always in a direction towards this point. Gravity, therefore, acts in the direction of lines converging or meeting at the center of the earth, a point so far distant compared

* This attraction is a mutual one. All terrestrial bodies as certainly attract the earth as they are in turn drawn to it; but the intensity of the force which they exert is so small, by comparison, that it is not considered. Gravity is but a special case of the universal law established by Sir Isaac Newton, that every particle of matter in the universe attracts every other particle. It is this mutual attraction between the sun, the earth and all the planets that holds the latter in their orbits.

with the dimensions of any bodies that are likely to be considered that these lines of action are always assumed to be parallel.

The question naturally arises, at what point in a body does gravity act? The answer is, at every point. All bodies are composed of particles, each of which has weight, and consequently is attracted by gravity. A body, therefore, is really drawn downward by a large number of forces of gravity—as many as there are molecules in the body.

It is always assumed, however, that gravity acts as a *single force* at a point called the *center of gravity*. In Fig. 6 let the dots p, p, etc., represent particles of the body B, under the influence of forces of gravity, acting in parallel lines in the direction of the arrows. Now, into whatever position this body be placed, there is always one invariable point through which the resultant of the attracting forces always passes. This point is called the center of gravity. It is a point, as $c\ g$, in Fig. 6, at which, if a single force of gravity were to act, in place of all the other forces, and equal in intensity to their sum, the effect upon the body would be the same as before. Again, since the intensity of the gravity force at each particle may be taken to represent its weight, and the sum of these forces the weight of the body, we may consider the center of gravity as a point at which the weight of a body is concentrated.

* * *

WHY A PUMP REFUSED TO DRAW WATER.

Wm. M. Francis.

Most every one has heard of the Yankee engineer who, on being asked by an examiner, when trying to get his papers, "If your pump was in thorough working order and would not draw water, what would you do?" replied: "By gosh, I would look over the side and see if there was any water in the Atlantic Ocean."

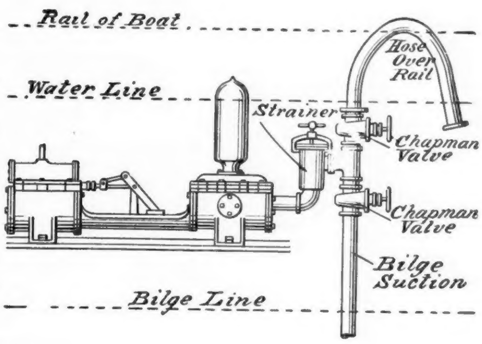
I will now relate a somewhat similar experience in which, although it may seem paradoxical, the pump was all right and the Atlantic Ocean full, yet the pump would not draw from there, although it would from any other connection.

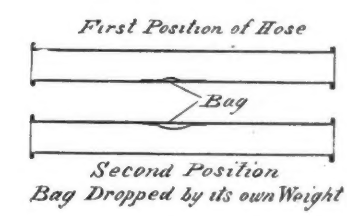
A yacht having been sunk, one of our coast wrecking steamers was sent out to raise her, if possible, by the ordinary means, *i. e.*, closing hatches, etc., and then pumping the water out through a line of hose run from the wrecking boat.

Everything was going along nicely when suddenly the pump refused to take any more water from that source. The yacht went to the bottom again and the engineer of the wrecker naturally looked over his valves and other apparatus, but without finding anything apparently wrong. The packing was also all right. After trying all manner of expeiiments the boat was put for a shop and a man called to look for the trouble.

By referring to sketch the arrangement of pipes will be seen. After the pump had been thoroughly looked over we began some experiments which were somewhat puzzling in their results. The pump would take water from the bilge with an approximate lift of five feet, or from a tank which was connected to the same pipe, although in this case water would run into the pump. In each case a full 6-inch stream was the result, but as soon as it was connected to the hose a few sputters was all that could be got. One would naturally say there was something in the hose that had no right to be there, but there was not; at least we took the hose down and looked through it, as it was in about 3-foot lengths, with flange couplings. We coupled it up again and threw the the end overboard, with the same result. We next hoisted the end up and poured water through, first taking the cap off the strainer. There was no obstruction. Then we took a piece of pine board, bored a hole in the center of it to fit the screw of a vacuum gauge, put a rubber gasket on the flange of hose and clapped the board on while the pump was running. The gauge showed 27 inches vacuum, so there could be no great leak in the hose. Now, as I had never had a similar experience before, it seemed to me to be very puzzling.

In the meantime the captain was getting impatient, swore considerable and finally said he would have the maker of the pump fix it if it was the Supreme Being himself. Accordingly a man was sent for from the pump works, and as I was interested and wished to know what really was wrong, asked to stay and see the proceedings. The engineer declared something leaked, the captain that the pump was no good, and I thought that there was either an unknown quantity in the suction or some one had hypnotized or hoodooed it.





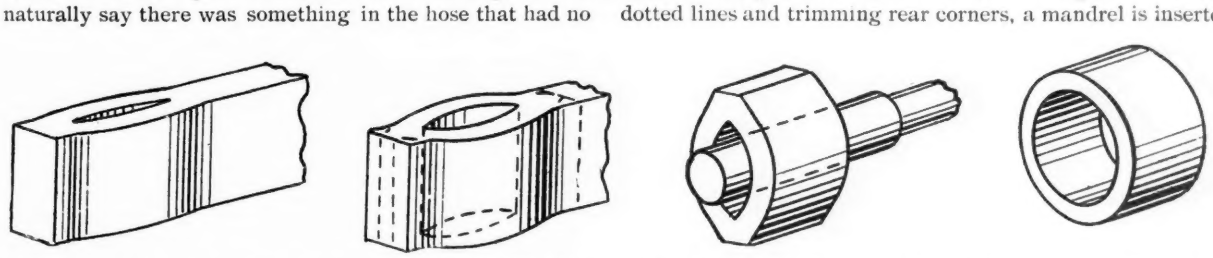
Well, the other expert went through the same performance, with the exception that the gauge was screwed on the pump drain cock-hole, and then the clapmans and iron pipe were examined. I confess that I had to smile at "the maker of the pump," but finally we got down to the hose again, and this time on looking through it we had it turned the other side up and could see quite a wrinkle inside of it. Here was the trouble. Those familiar with air-pump experiments know that when an elastic bag or rubber ball is put under the receiver and the air exhausted from the receiver that the ball will swell or the air contained in it will expand. It was so in this case. We could pour water through the hose, or in one position of it see through without any obstruction, but as soon as the end was put in the water and the end closed, in that way it became a receiver, and the little bag in the lining expanded when a vacuum was created and filled the hole.

Of course all had a laugh, that it took so long to discover such a simple thing.

* * *

MAKING A WELDLESS RING.

As most people consider that the welding of tool steel is an uncertain operation, many specify that their forgings shall be without a weld, which often makes the work very difficult. Several years ago a contract came to the shop for a lot of tool steel rings, 4 inches long by 5 inches outside diameter, and about half an inch thick, and without a weld. Here was a puzzle, but at last one of the men conceived the idea which is illustrated in the following cuts, and which almost form a story without words. Beginning at the left there is a bar of steel of the required size for the ring (which was found by a little experimenting), which is opened down through with a hot cutting chisel and widening the cut as shown in the second figure, trimming the two front corners before cutting from the bar. Then cutting off as shown by dotted lines and trimming rear corners, a mandrel is inserted and a short treatment under the drop hammer soon rounds it up, as shown on the right, a little practice soon showing just how much stock to allow and the amount of hammering.



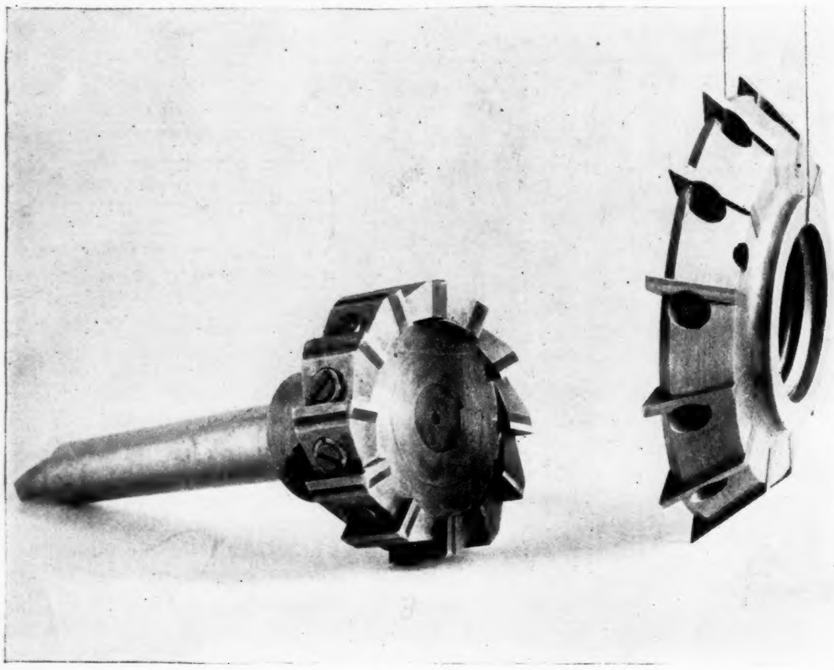
* * *

Twist Drill Clearance.—If the clearance of a twist drill is not perfect, the drill will not cut; the application of power to force it to cut will either crush or split. The proper angle for the cutting edge is 59°.

INSERTED-TOOTH MILLING CUTTERS.

Robert Grimshaw.

While going through the shops of the Brown & Sharpe Mfg. Co., I saw a good many things which are not to be met with in the majority of machine-shops in this country. Among them was a form of milling-cutter with insertable teeth, the hub or center in which they were held, being of cast iron arranged to be keyed to an arbor, and having on its circumference half as many spaces as there are to be inserted teeth. The fronts and backs of the projections forming or formed by the spaces are milled off smooth and radial, and the teeth, which have full fronts and backs, are slipped in in pairs so that the front of one fits against the back of one projection, and the back of the one directly behind it comes against the front of the projection next back. This leaves a wedge-shaped space between the back of the front tooth of the pair and the front of the back one. Into this there is slipped a wedge-shaped piece of cast iron, which is bored lengthwise to receive a screw that enters the hub or center radially and which, on being tightened up, draws the wedge towards the center of the hub and crowds the inserted teeth against the projections. The amount of projection of the teeth may be varied by packing pieces of paper, as for instance when after grinding they have become slightly shorter, or if it be desired to give every other one a trifle extra working depth.



FIGS. 3 AND 4.—INSERTED-TOOTH MILLING CUTTERS.

Cutters thus made have the advantages that they are much cheaper in first cost than solid cutters; that the form of the teeth may be altered at will, each cast iron hub or center having if desired several sets of teeth of varying profile or width; and the destruction of any one of the teeth does not ruin the entire tool. The sharpening, also, may be done most efficiently with minimum trouble, and calls for less skill and simpler appliances than the grinding of the solid cutters.

A front view of such cutters is shown in Fig. 1, and a side view in Fig. 2.

A variation of application of this principle is seen in Figs. 3 and 4, in which there is but one tooth for each space between the projections; and the teeth are held in by radial screws passing through conical steel thimbles relieved on one side and passing through the projections so as to lock the teeth in place.

In both styles the hub is keyed to the arbor of the milling machine in the ordinary fashion.

* * *

Don't let a few cents prevent your buying the best steel.

SOME NOTES ON UPSETTING STEEL.

Boyd Harriman—T. D.*

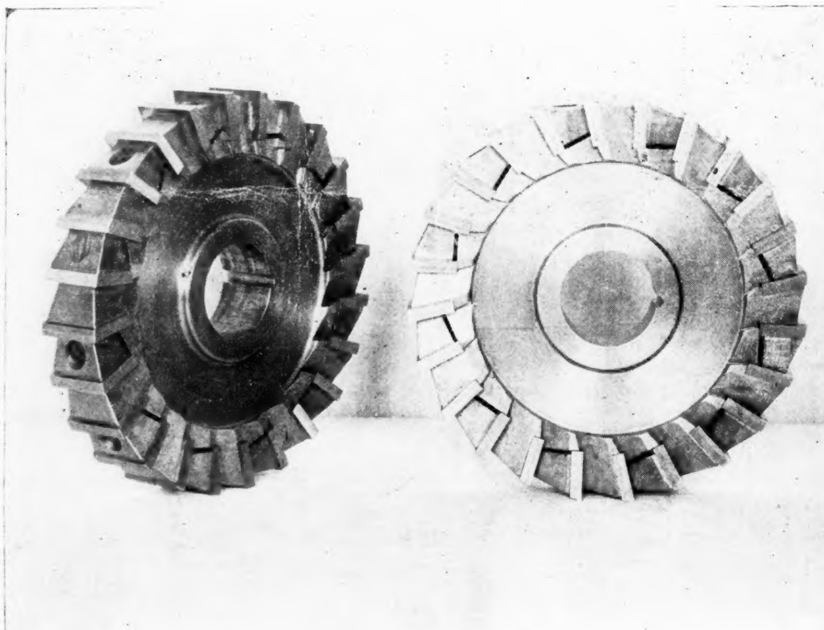
By upsetting steel we mean shortening it—compressing it endwise. The stock which is forced back is distributed in the width, or thickness, or in both. The process of upsetting is, therefore, used to make available, in width or thickness, the material in superfluous length.

Objections are made to having any upsetting done on cutting tools. These objections are founded on the theory that in all tool steel there is a liability to short seams, caused by hammering down the minute blow holes which occur in the cast steel ingot. Upsetting would be likely to alter the shape of these seams. It might, perhaps, give them a T shape, or cause them to stand directly, or obliquely, across the line of the tool. This would be equivalent to cutting off the strength of the tool to an equal amount.

These irregularities and defects, although quite small, as they are allowed to be, individually, are suspected of becoming consequential in the aggregate, and peculiarly annoying in a turning tool, or one that depends upon its transverse strength for its efficiency. If the upsetting of the steel really produces cross checks, it of course lessens to that extent the capacity of the steel to resist the transverse strain to which it is subject in cutting its chip.

One of the directions with which the T. D. —tool-dresser—is most frequently favored when he is dressing a cold chisel, is the caution not to upset it. This is rather funny when the whole office of the chisel is to utilize at its edge the blows struck endwise on the head. This is the reason that, when the docile tool-dresser hears such a caution given, he is paralyzed with blank astonishment and exclaims: "Upset it! What, I! Upset a cold chisel! I'd as soon think of upsetting the ten commandments!"

A farrier was once asked why he would not shoe a horse as a customer directed him to. He replied: "If I shoe the horse as he orders, and the horse's lameness gets worse—which it will—will he tell every one that I shod it according to orders? But if by some miracle the horse should forget to go lame, is there any one he won't tell that I shod it according to his orders?" "I give it up! What's the answer?" "The answer is, that if he knows more about shoeing horses than Robert Bonner, he can take my fire and I'll slide out into the shade and read the New York Ledger."



FIGS. 1 AND 2.—INSERTED-TOOTH MILLING CUTTERS.

* Tool-dresser.

Every tool-dresser should be courteous and obliging, for he does not know it all, and some kid may some day infest his brain with a stinging new idea; but no tool maker has any right to make a tool, or work his steel, in any manner that his judgment does not approve, unless he can produce irrefutable evidence that he has done so under positive orders and under protest. Men are very much too fresh in laying all the errors they make on the shoulders of others, and at the best, the tool-dresser has to suffer for the transgressions of many.

It is not uncommon for a shop to use a number of different brands of tool steel. Now the human intelligence is totally inadequate to the task of keeping soft steel out of tool steel if there is a particle of it on the premises, and how any one can be expected to keep different kinds of tool steel separated—unless they keep a witch—is altogether beyond the ordinary tool-dressers comprehension.

It has been proposed that the different kinds of steel be painted in different colors, and the different limbs of the tool-dresser be tinted to correspond so he could remember, but he might sweat and one color run into another, or he might get scared and then they would all run together. The only possible way to keep different kinds of steel separate is to have distinct lockers for each kind, and when one kind is wanted, carry back all of any other kind that is on hand, get the kind that is wanted, and carry back all that is not used, and then, some day, something will happen that these conditions are not complied with, and then comes the inevitable mingling and inextricable confusion. Such is the universal experience.

If the tool-maker is requested not to upset the steel he is using, whatever "make" it may be, it will not put him out a great deal to widen a chisel by hammering it thinner, and there are other compensations for other things. Above everything he should be perfectly straightforward and outspoken, or he cannot keep track of his own work and know how to improve upon it. Whatever kind of miserable substitute for steel is brought to him to work, his own conscience will compel him to treat in the manner which his experience teaches him will be most likely to produce the best results, however annoyingly unsatisfactory those results may be. His employers will come to accept his statements as verities, when his services have attested his skill, fairness and faithfulness.

If there is commonly much unwelded seam in cast steel it will show itself in such tools as lathe side tool, or in reamers, and taps, and in drills. It will be very apparent in such cutlery as knives, razors, scythes, machetes and other tools and instruments which have the edge longitudinal, because it is evident that the length of such a seam would, in such blades, appear by the loss of an equal portion of the edge. As nothing of the sort is observed in good cutlery, it is evident that whether the blow holes, which tend to result in seams, are soundly welded in the interior of the bar or are not, those which are near the surface are thoroughly purged of foreign matter and are lost in the thoroughly united mass.

What better would cast steel be than double shear or blister, if the result of fusion was not to make the mass homogeneous. No substance is perfectly alike in its physical characteristics throughout its mass, close inspection discovers its deformity, but as cutlery improves by grinding and gets better the more it is worn—prejudice and perversity to the contrary notwithstanding—so we have reason to suppose that the steel of the present is fairly homogeneous in structure, and not likely to have its tenacity or any other valuable qualities injured by the process of upsetting.

* * *

HOW FAR IS THIS TRUE.

"When I see bicycle makers advertise different wheels at different prices, when to all appearances the only difference is a few details and the name plates," said a mechanical friend of ours, "it reminds me of a story they tell in Tampa, Florida, about a hotel there where they 'size a man up' before rendering a bill. Once a quiet little man came in and stayed three days, when he asked for his bill. The clerk looked him over and said, 'Thirty dollars.' The quiet man pulled out the money and said, 'You better guess again, I've got more than that.' So with wheels. If you don't look as though you had $100 they trot out another name plate and charge you $60. While this may not be altogether true, it is safe to say that there is not the actual difference in quality between the two machines that warrants the difference in price of from $25 to $50."

MEASURING ANGULAR WORK.

J. T. Giddings.

Measuring angular work is difficult for the beginner in machine work, and quite often for the older hands as well, and to my mind there is good reason for its being so. It requires some knowledge of the practical application of geometry, and there are various bevel protractors in use, some of which are graduated so that if the blade is at right angles with the stock the pointer of protractor is at zero or o, while with others the blade is square with the stock when the pointer is at 90°.

The latter way is the proper one in my opinion, although the former seems more convenient in some places, which I will explain farther on.

But sometimes different men with the same bevel protractors will measure angles in a different way.

As an illustration, a common beveled head machine screw and angle templet of same as in Fig. 1 was handed to A, B and C to measure the angle of screw head. A gave for the angle 38°, B 52° and C, after measuring and calculating, said it was 76°, and yet all three thought they knew how to measure angles; but it is obvious that all three answers would not be accepted as correct.

The pointer of the protractor shown in Fig. 2 is at 38°, this protractor is graduated so that if the blade is at right angles with the stock the pointer is at 90°. The pointer being at 38° in the sketch, indicates the angle from a vertical line or the axis of the screw, and if the angle was measured from a horizontal line or parallel with the flat top of screw head, the angle would be 52° and should be counted backwards from the 90° mark to the pointer, or by subtracting 38° from 90° we obtain the complement of the angle of 38° which is 52°. If the angle of screw head was considered as the angle of the two sides converging to a point on the axis of screw, then twice the angle measured from the axis of screw would be the included angle of the sides or 76°. This would be about the angle of cutting edges of a countersink for a standard machine or wood screw. A pair of V blocks, as in Fig. 3, were to be made for shop use, and the foreman instructed the workman to plane the V's at an angle of 45°. The workman had some experience with angular work, so he laid out the angle $22\frac{1}{2}°$ each side of a center line and asked the foreman if that was correct. The foreman replied that he wanted the swiveling head of the planer set over for 45°. This, of course, would make the angle of the V's 90°. Some might say that if the head was set for 45° that was the angle to call it. But let us consider another case.

A workman was given a job to be planed up at an angle of 60°. The work was blocked up on the planer so that the zero line (the line from which the angle was measured) was horizontal on the planer although it was vertical on the drawing. The swiveling head was set over to 60° and an expensive forging was spoiled; and the workman thought the drawing was at fault.

Figs. 4 and 5 are end views of a die and die block.

In Fig. 4 the side $a\ b$ is required to be planed up at an angle of 50° with side $a\ d$. If the work was clamped on a planer with side $a\ d$ horizontal or parallel with planer table, the swivel head would not be set to 50° unless (as is seldom the case) the head was graduated, so that if it was in its vertical position the mark or line on saddle would coincide with the 90° graduation. The swivel head is usually graduated so that if it is in its vertical position the zero or o would coincide with the line on saddle. If in the triangle $a\ b\ c$, Fig. 4, the angle $b\ a\ c$ is 50°, the angle $a\ b\ c$ is the complement of the angle or $90°-50°=40°$, this would be the angle to set swivel head with side $a\ d$ in a horizontal position. If side $a\ d$ is clamped in a vertical position the swivel head would, of course,

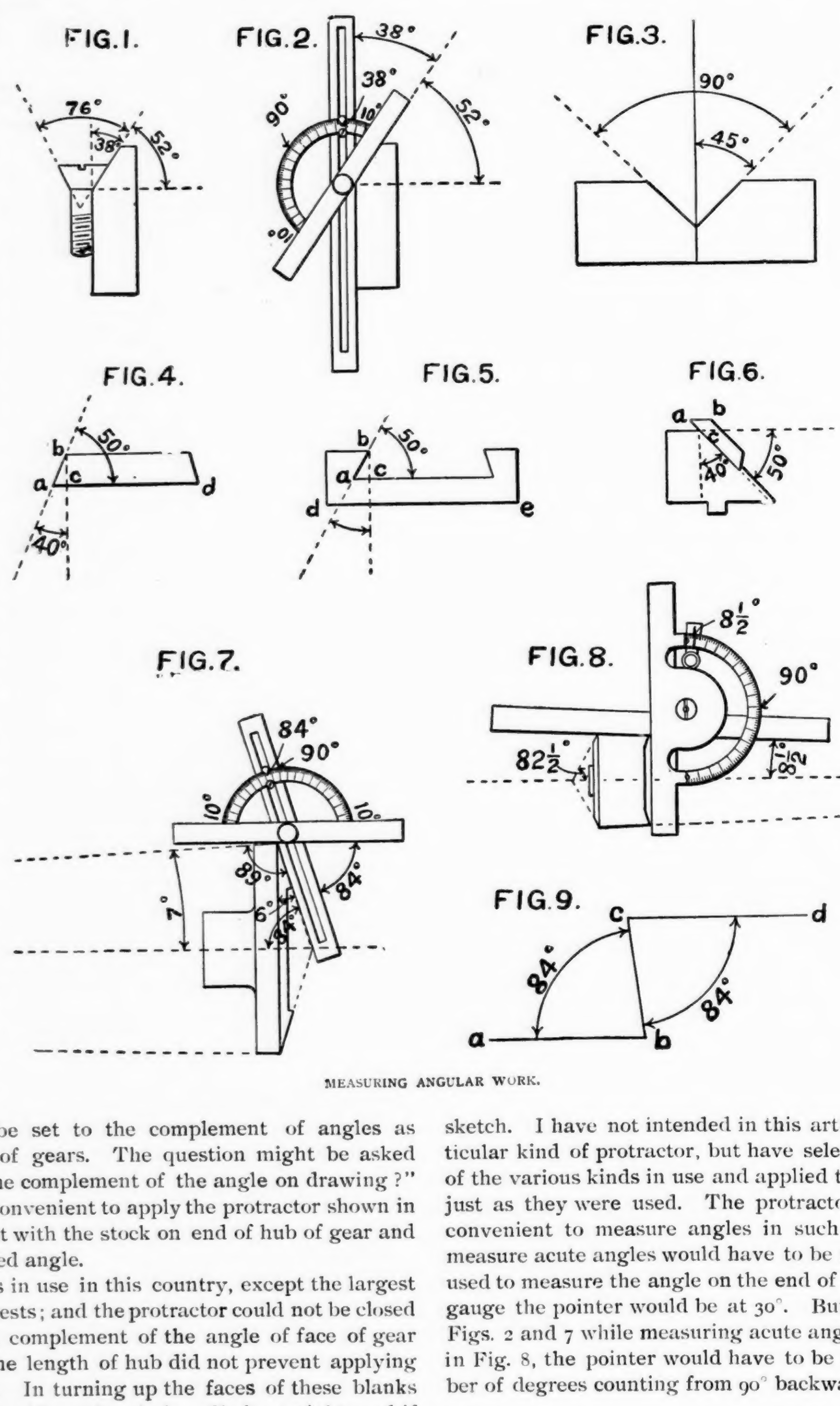
be set over to 50°. The die block, Fig. 5, would be planed with side *d e* horizontal, and if the drawing gave the angle *b a c* as 50° the swivel head would be set to the complement of the angle or 40°. It might be said that a draftsman should consider how a job was to be blocked up on a planer and place the zero line on drawing to correspond, but the draftsman would probably say that the workman should consider whether the zero line was vertical or horizontal from the position of the work on the planer. If many pieces like Fig. 4 were to be planed up, it would pay to have a fixture made as in Fig. 6, for holding the work in such a position that the side *a b* could be planed by feeding across the work the usual way, not setting the swivel head over.

The angle to which the head would be set to plane this fixture would be the complement of the angle *c a b* or 40°. Perhaps as good an example as any in the use of the bevel protractor is furnished in turning up a pair of bevel gear blanks. Of course they could be turned up from angle templets made to drawing. The full diameters of the gears could also be obtained by measuring the drawing, but this is not the most satisfactory way of doing it. The diameters and angles for bevel gears can be obtained by calculation requiring some knowledge of trigonometry, or they could be obtained for proportions from 1 to 10 by the Bevel Gear Chart of Geo. B. Grant, requiring only a knowledge of common arithmetic. Suppose we have a drawing of a pair of bevel gear blanks with the angles of the face and edge marked from the center line or axis of gears, as in Figs. 7 and 8. After turning the blanks to the proper diameter and squaring up the sides, the next thing in order is to turn the angles.

If a graduated compound rest is used and the angles of gears measured from center line as in sketches, and the line of travel of tool slide is square with the line of centers of lathe, when the zero mark coincides with line or mark on saddle, the rest should be set to the complement of angles as marked from the axis of gears. The question might be asked "then why not mark the complement of the angle on drawing?" It would also be more convenient to apply the protractor shown in Fig. 2, as it could be set with the stock on end of hub of gear and blade set to the required angle.

But few of the lathes in use in this country, except the largest sizes, have compound rests; and the protractor could not be closed enough to measure the complement of the angle of face of gear (6°) in Fig. 7, even if the length of hub did not prevent applying protractor in this way. In turning up the faces of these blanks we take say a common side tool, grind or file it straight, and if the gears are cast or forged, we first take the scale off with another tool.

Then to set the protractor to measure the angle of face of gear (Fig. 7), it was found that the only way this form and size of protractor could be used was as in Fig. 7, with stock parallel to axis of gear resting on the part previously turned straight. We could first set the blade square, the pointer being at 90°, then move the blade one side to the complement of the angle of face (84°) which is 6°. The protractor would then be opened just 84° from the zero mark, which is the angle of face measuring from the axis of gear, why this is so can be explained by a proposition in geometry that "if a straight line meet two parallels the alternate angles will be equal." In Fig. 9 the two parallel lines *a b* and *c d* are connected by the line *b c*, making an angle with *a b* of 84°, then by the proposition *b c* also makes the same angle with *c d* of 84°. The cutting tool could be set by the "cut and try" method, which in this case would be quicker than making angle templets. After the angle of face is turned, the protractor is set to measure the angle of edge, which is marked 7° from the axis of blank produced. The blade of protractor could be set over just 7° from the position shown, to measure the angle of edge. This would bring the pointer on protractor to one degree the other side of the 90° mark and would read 89°, this angle is the complement of angle of edge (83°), + the complement of the angle of face (6°).



MEASURING ANGULAR WORK.

The angle at the bottom of face could be obtained on blank by setting cutting edge of tool parallel to edge of gear. To measure the angles of bevel pinion, Fig. 8, a different protractor is used graduated in a different way, so that if the blade is set square, with the stock the pointer is at zero or 0. Of course the protractor shown in Fig. 7 could have been used satisfactorily by measuring the complement of the angles marked on drawing and applying the stock on end of hub of pinion, but I chose this one to illustrate how it can be used for this and similar work. To measure the angle of face the pointer is set to the angle marked on sketch of 8½°.

The angle of edge was measured by the stock of protractor placed on hub of pinion and the pointer indicating 82½° as per sketch. I have not intended in this article to advertise any particular kind of protractor, but have selected two different makes of the various kinds in use and applied them to measuring angles just as they were used. The protractor shown in Fig. 8, while convenient to measure angles in such cases, if it was used to measure acute angles would have to be read backwards, if it was used to measure the angle on the end of a Brown & Sharpe center gauge the pointer would be at 30°. But the protractor shown in Figs. 2 and 7 while measuring acute angles correctly if applied as in Fig. 8, the pointer would have to be set to the required number of degrees counting from 90° backwards.

* * *

A COMBINED belt-shifter and brake for such machines as vertical jig-saws, has a brake so fastened to the lever of the belt-shifter as to rub against the flat side of the first pulley, after it has thrown off the belt.

MACHINE SHOP ARITHMETIC.

A series of practical articles clearly explaining the portions of mathematics which will be useful to the men in the shop and engine room.

PRACTICAL QUESTIONS CONNECTED WITH THIS SUBJECT WILL RECEIVE PROMPT ATTENTION.

MAKING AND USING FORMULAS.

CALEB TOPHAM.

Formulas are such a useful feature in the arithmetic of the mechanic, or perhaps it would be more correct to say abbreviation or condensation of the arithmetic, that they should be better known and appreciated by him, as they will shorten his calculations and help him to become much more familiar with the rules used in standard practice among mechanics and engineers. Knowing from a fairly long shop experience that shopmen as a rule seem to have a horror of all formula, imagining them difficult or puzzling and only useful in confusing those who have not had opportunities in mathematical education, I wish to show them how useful formulas are, how they shorten calculation, how they economize space, and how much more convenient they are to remember than long-winded rules, and hope to make it clear even at the risk of being too elementary in the explanations. There seems no better way of making their simplicity evident than by showing how they are *made*, how they are *used*, and their *advantages*, ending with illustrations from everyday practice. To begin with, a formula is simply an arithmetical rule in which all words are omitted, all the quantities represented by letters and figures, and all the operations are indicated by signs and by the position of the different characters. This may sound hard—but it isn't. We know from our arithmetic that the area of a rectangle is found by multiplying one side by the other, or calling one side A and the other B, we can say "A multiplied by B equals the area." To go a little farther, to call A=10 inches, B=20 inches, then the area will equal A (10)×B(20)=200 square inches.* as in Fig. 1 A To state this correctly we say:

Let A=short side of rectangle.
" B=long " " "
" C=area.
Then C=A×B.

As one of the handy features of formula is the ease of transposition, or of changing the "rule" to find any one quantity, the others being given, we can show this way nicely in this simple case and shall do so as we proceed with other problems. We might have the area and the short side given to find the long side (b) or to find the long side (c). Then as C=A×B (a),

$$B=\frac{C}{A}\ (b) \text{ and } A=\frac{C}{B}\ (c),$$

or in figures, C=10×20=200 (a), $B=\frac{200}{10}=20$ (b), and $A=\frac{200}{20}=10$ (c). Going now to another case we take the circle and learn that the relation between the diameter and the circumference is as 1 to 3.1416 (near enough for practical purposes), or in other words, that a circle 1 inch in diameter has a circumference of 3.1416 inches, or one of 2 inches has a circumference of 6.2832 inches, so we say: Diameter (d) multiplied by 3.1416 equals circumference in the same measure or unit as the diameter, or D×3.1416=C or circumference. This relation has come to be known as "pi" and represented by π, which means that the sign π stands for the number 3.1416 as $\pi d=3.1416\times$ diameter, which of course equals the circumference or periphery. Having a pulley 10 inches in diameter, we wish to find how fast the rim is traveling in feet per minute, the revolutions being 200 per minute. The circumference equals 10×3.1416(diameter × π)=31.416 inches, which, divided by 12, gives 2.618 feet. Now to make our formula we say:

d=diameter in inches.
π=3.1416.
c=circumference in inches.

Then

$$d\times\pi=c \text{ or } \frac{d\times\pi}{12}=c \text{ in } feet$$

As it is running 200 revolutions per minute, 200×2.618=523.600 feet per minute, or combining this in the formula and adding r=revolutions per minute and F=feet per minute that rim travels,

$$=\frac{c\,r}{12}$$

to above notation we have

$$F=\frac{d\times\pi\times r}{12} \text{ or } \frac{d\pi r}{12} \text{ or } \frac{c\,r}{12}=\frac{10\times3.1416\times200}{12} \text{ or } \frac{31.416\times200}{12}=523.6$$

feet per minute.

This can be transposed to find any of the quantities and as we wish to be thorough in all we do, we transpose as follows:

$$C=d\times\pi, \text{ and } d=\frac{C}{\pi},\ F=\frac{d\times\pi\times r}{12} \text{ or } d=12\frac{F}{\pi\times r}$$

because, d being in inches and F in feet, it is evident that the speed in feet, divided by "pi" times revolutions, must be multiplied by 12 to reduce it to inches. Then

$$r=\frac{F\times12}{\pi\times d}=r=\frac{523.6\times12}{3.1416\times10}=\frac{6283.2}{31.416}=200$$

and with these three transpositions of the formula any desired factor can be obtained.

Taking the area of the circle next we find that the diameter squared (multiplied by itself) and multiplied by the constant number, .7854, gives the area. The area of a cylinder 12 inches in diameter will then be 12×12×.7854=113.09 square inches; calling the diameter d and a the area, we say $d^2\times.7854=a$.

What is the total pressure on a steam piston 10 inches in diameter, steam pressure 100 pounds per square inch? In this case d=10, then $d^2\times.7854=10\times10\times.7854=78.54\times100=7854$ pounds total pressure on piston. Now, taking a cylinder twice this diameter, with the same pressure, we have d=20, 20×20×.7854=314.16×100=31,416 pounds of total pressure, or *four* times the former case, although the diameter is only *twice* as large. This brings us to the "law of squares," which is simply that *areas of similar figures vary as the squares of similar dimensions*, diameter in this case, the other cases will come later. This shows that in any cylinder, tube or shaft, the areas vary as the square of the diameters, and that a 2-inch tube has four times the area of a 1-inch tube, or a 3-inch cylinder has 9 times the area of a 1-inch cylinder (because 3×3=9, while 1×1=1), while the areas of two holes, 3 and 5 inches respectively, are as 3×3=9 and 5×5=25, or as 9 is to 25, or if one will pass 9 cubic feet of air or water per second, the other will pass 25. Having found the area of a shaft, we have only to multiply this by the length to find the volume or cubical contents, and knowing this we can estimate very closely the weight of different substances, by multiplying the number of cubic inches it contains by the weight of one cubic inch of the material. Putting this into a short formula we have:

d=diameter in inches.

l=length in inches, or $\frac{l}{12}$=length in feet.

c=constant.

Then $d^2\times.7854\times l\times c$=weight of any round shaft or bar.

What will a steel shaft weigh 2 inches in diameter and 10 feet long? Referring to table of weights of metal on page 164 of Kent's Pocket Book we find steel given as .283 pounds per cubic inch—then in this case c=.283. Then 2×2×.7854×10×12×.283=106.68 pounds as weight of shaft. Transposing once more we find that as $d^2\times.7854\times l$=cubical contents (a), then

$$d=\sqrt{\frac{a}{.7854\times l}}$$

* It is evident that the area will be in square measure of whatever unit the sides are; in this case square inches. The multiplication sign is not necessary between letters, as A and B in this case, and is often omitted, C = A B meaning that C = product of A B. In some English works multiplication is denoted by a period where we usually place the decimal point, this point being placed half way up the figure, as A.B means A x B, while 3·5 = 3.5 or 3½.

or square root of

$$\frac{376.99}{.7854 \times 120}$$

which must be solved, and the square root of this result equals d. In the same way we transpose for l when

$$l = \frac{a}{d^2 \times .7854}$$

If a shaft must have a certain weight, first divide this by the weight per cubic inch, which will give the required cubical contents, and the result can easily be found by the formulas given. Of course we can transpose the whole formula, including weight, but it would only add to the number of formula without being necessary.

Before going on with useful shop formula, let us take a "horrible example" and see how it is solved, which will perhaps clear up some of the mysteries better than the simple formulas. Taking

$$A = \frac{b}{2}\sqrt{a^2 - \left(\frac{a^2+b^2-c^2}{2b}\right)^2}$$

were $a=3$, $b=5$, $c=4$. The fraction being enclosed in the brackets, indicates that it is to be considered as *one* number, and after being squared, subtracted from a^2, and the square root of this difference multiplied by

$$\frac{b}{2} \text{ or } \sqrt{9 - \left(\frac{9+25-16}{2 \times 5}\right)^2}$$

$= \sqrt{9-3.24} = \sqrt{5.76} = 2.4 \times \frac{5}{2} = 6 = A$. If the brackets included all the figures under the vinculum (bar from square root sign) the calculations would be

$$\sqrt{\left(9 - \frac{9+25-16}{2 \times 5}\right)^2}$$

$= \sqrt{(9-1.8)^2} = \sqrt{7.2^2} = 7.2 = A$, so that special care must be taken to follow the signs correctly. These particular points will be shown as we proceed.

Taking the formula for the area of a ring where $A = .7854 (D^2 - d^2)$

D=outer diameter.

d=inner diameter.

A=area in square measure of whatever unit the diameters are given in, if D and d are inches, A will be square inches, etc.

D=10 inches d=6 inches. Then $A = .7854 \times (D^2 - {}^2)$. The brackets denote that this part must be solved first. $10 \times 10 = 100$, $6 \times 6 = 36$, $100 - 36 = 64$. $A = .7854 \times 64 = 50.26$ square inches. By adding l=length to the formula we can find the cubical contents and weight of any hollow cylinder or pipe, and calling this one 12 inches long we have $50.26 \times 12 = 602.6$ cubic inches, from which weight can be found for any material. As an example of working backwards, find the thickness of a cast iron cylinder whose outer diameter is 10 inches, length 15 inches, and which must weigh 200 pounds. Cast iron is given as .26 pound per cubic inch. So dividing 200 by .26 we find that $(200 \div .26 = 769.23)$ 769.23 cubic inches are necessary to make the required weight. Dividing this by the length, 15 inches, we have 51.28 square inches as the area of the ring whose outer diameter is 10 inches. Then we can say $51.28\ (A) = .7854 \times (100 - d^2)$ and transposing we have

$$d = \sqrt{D^2 - \frac{A}{.7854}} = \sqrt{100 - \frac{51.28}{.7854}} = \sqrt{34.71} = 5.89$$

inches internal diameter.

It takes study and thought to work a problem backward, espepecially where squares (or cubes) and square (or cube) root are used, and while it is advisable for all to become familiar with this, and to reason out the different cases, we give all the tranpositions likely to be needed to save time for the reader and to have them for reference. A few symbols that are frequently used are given below.

π called "pi" = 3.1416.

d^2 called exponent = d squared or multiplied by itself.

d^3 called exponent = d cubed or multiplied by itself twice, d^4=d fourth, etc., meaning to fourth power of d.

$\sqrt{}$=square root—when bar extends over figures thus, $\sqrt{2+7} = 3$ = square root of sum. This can also be represented by $\sqrt{(2+7)} = 3$ as before, the brackets showing that all within them are to be taken as one figure. $\sqrt{9}+2 = 3+2$, as the root is only taken from first figure.

$\sqrt[3]{}$ = cube root, $\sqrt[4]{}$ = fourth root, $\sqrt[5]{}$ fifth root, etc. Fourth root can be found by extracting square root twice; roots above this can best be found by logarithms, as explained later.

$\therefore$ = Therefore.

The signs must be carefully watched, as all depends on interpreting them correctly; care will do this, however, and attention will be called to this in each case.

Examples.—1. What will a steel cylinder 24 inches long, and diameters 10 and 1 inches respectively, weigh, taking steel at .285 pounds per cubic inch?

2. What will be the length of a 4-inch cast iron shaft which weighs 85 pounds?

3. Solve

$$W = \frac{3.1416 \times D^2 \times T \times S}{2}$$

when D = 12, T = .25, S = 35.000 and L = .250. This is D. K. Clark's formula for the strength of hollow tubes, and W = breaking load at center in pounds. D = extreme diameter in inches, T = thickness of tube in inches, L = length between supports in inches, and S = ultimate tensile strength in pounds per square inch.

* * *

HOW AND WHY.

A COLUMN INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST. GIVE ALL DETAILS AND YOUR NAME AND ADDRESS, WHICH WILL NOT BE PUBLISHED UNLESS DESIRED.

7. J. Y. M., Richmond, Va. 1. The statement made in Forney's Catechism regarding falling bodies: "In each successive second the distance that a stone falls is 16.1 feet more than that through which it fell the preceeding second," is not clear to me, as, according to the chart it falls 16.1 feet the first second and 48.3 the second, which is the distance of the first second plus 32.2 instead of plus 16.1 feet! *A.* The velocity is 32.2 feet at the end of the first second and gains this amount each second, so that at the end of the 10th second it will be 322 feet per second. The space fallen through in any second is the number of the second multiplied by 16.1 feet, as the 5th second would be $5 \times 16.1 = 80.5$ feet, the space fallen through in the 5th second. The total space fallen through varies as the *square* of the time in seconds; thus, while the velocity at the end of the third second is 96.6 feet or three times that of the first second (32.2) the total distance fallen is 9 times ($3 \times 3 = 9$ or the square of 3) the total distance of the first second, or $9 \times 16.1 = 144.9$ feet. The difference in space passed through each second is 32.2 feet as you make it. The charts show the velocity at the end of each second.

8. G. I. B., Pawtucket: 1. How can I find the exact diameter of a pulley to run a certain number of revolutions, to include the thickness of belt? *A.* Suppose the driving pulley is 10 inches in diameter and runs 150 revolutions per minute and we wish to have the driven pulley run 100 revolutions. Neglecting the thickness of belt we have 100 : 150 :: 10 : 15, or we can say diameter of the driver multiplied by its revolutions and this product divided by the revolutions of the driven pulley gives the diameter of driver. To account for the thickness of belt you simply add half its thickness to *radius* of pulley or its whole thickness to the diameter of driving pulley and proceed as before. The result gives the diameter of driven pulley *plus* thickness of belt; so deduct this from result of actual diameter of pulley. 2. What is the allowance for forcing fits? *A.* While this varies with the work in hand, owing to difference in thickness of metal around the hole and other conditions, a rule often used is: Apply 6 tons pressure per inch of diameter and allow about .004 per inch for forcing fit. In the case of a 4-inch crank-pin this gives $6 \times 4 = 24$ tons for pressure and $4 \times .004 = .016$ for forcing fit which is very near general practice, although a higher pressure is used in some places.

9. U. P., Sacramento, asks: How do you calculate the breaking and working strain for manilla rope? *A.* One authority gives $720\ C^2$ as breaking strain and $\frac{1}{36}$th of this or $20\ C^2$ as maximum working strain, C being the circumference of rope. 2. We have an $1\frac{3}{8}$ inch diameter rope, running 4,500 feet per minute with 21 grooves in fly-wheel, what power should it transmit? *A.* According to the above formula the working strain would be $20\ C^2$; $C = 1\frac{3}{8} \times 3.14 = 4.3$, $4.3 \times 4.3 = 18.5$, $20 \times 18.5 = 370$ pounds working strain, This at 4,500 feet per minute gives $4,500 \times 370 = 1,665,000$ foot pounds, divided by $33,000 = 50.45$ H. P. per rope. With 21 ropes this gives $50.45 \times 21 = 1059.45$ H. P. for this drive. This, however, takes no account of centrifugal force, which at this speed is an important factor. Tables of rope transmission give a $1\frac{3}{8}$ inch rope as driving from 26 to 28 horse power at the velocity given, which would make the economical figure for your drive $28 \times 21 = 588$ H. P., so that it is safe to say 750 H. P. is more than an economical load.

10. "Boiler," Chicago, says: I read in a lecture that increasing a chimney's height increased its efficiency but not its draft power, how is this? *A.* Increasing the height of a chimney increases the draft and increases the coal which can be burnt per square foot of grate; which many times will increase its efficiency. Many such statements are misleading, as they fail to give the

conditions, which greatly affect the results. There is much to be learned about boiler and furnace economy in general.

11. C. A. S. asks: 1. What is the average diameter of a Corliss valve for a 20 x 48 inch engine? *A.* A diameter of $5\frac{1}{2}$ inches is often used for this sized cylinder. 2. What are the dimensions of steam port? *A.* About $18\frac{1}{2}$ inches long by $1\frac{1}{16}$ inches wide, or an area of ($18\frac{1}{2} \times 1\frac{1}{16}$) 21.46 square inches. 3. Also dimensions of exhaust port? *A.* This is the same length, $18\frac{1}{2}$ inches by $1\frac{3}{4}$ inches wide, making an area of 32.375 square inches.

12. D. E. F. asks: 1. What is the difference, if any, between the average pressure and the mean effective pressure? *A.* This is an old question but on which many who know very well on sober thought become careless if hurried or not careful enough. Let us suppose a man pulls on a rope with an average pressure of 100 pounds, and on the other end is a boy pulling with an average pressure of 60 pounds in the opposite direction. The *average* pressure is 100 pounds, the *back* pressure (or resistance due to the boy) is 60 pounds, so that the *mean effective*, or useful pressure, is only 40 pounds, or in other words, this is the pressure that performs useful work and which would be all that is needed were it not for the opposition of the boy. In a steam cylinder we have a steam pressure which diminishes from the point of cut-off to the end of the stroke. The *average* of this is found by multiplying the absolute initial pressure by one, plus the hyperbolic logarithm of the expansion and dividing this by the number of expansions. Thus, taking 145 pounds gage pressure, $\frac{1}{3}$ cut-off, we have $145 \times 15 = 160$ pounds absolute (nearly, 14.7 is the correct figure, but 15 serves for illustration). The hyperbolic logarithm of 3 is 1.098, plus 1 equals 2.098. Then $160 \times 2.098 \div 3 = 111.89$ as the *average* pressure. If there were no back pressure, this would also be the mean effective pressure, but as this never occurs, the back pressure must be deducted from the average pressure before the *mean effective pressure* can be found. A little thought will prevent mistakes of this character, which are exasperating because of their simplicity.

* * *

ONE WAY OF LOOKING AT THE PIECE WORK QUESTION.

I. B. Rich.

The writer recalls a conversation with a superintendent of a large shop regarding the adoption of piece work and its beneficial effects on the cost of production, and an incident was cited of how the time had been reduced nearly one-half and the workman made about a dollar a day more than they could afford to pay. When asked to account for this great increase and output which necessitated (?) the cut in rates, the superintendent replied that much of it was due to the workman doing his planning and thinking *at home* instead of in the shop.

This is probably true to a large extent, and it brings to light sufficient reason for paying the workman considerably more than he had been receiving when doing less work, for his thinking at home was *work* by which the firm benefitted, and even if classed at the same rate as his manual labor, should have been paid as overtime.

There is no disputing the fact that the rate of wages depend upon supply and demand, but it is rather depressing to hear a man say he cannot afford to pay over a certain rate of wages, when by his own story the output of his plant has been much increased by the energy and "home thinking" of his men. If he could afford to pay $2.50 per day for making ten pieces (no matter what), how can he say he cannot afford to pay $3.50 for fifteen pieces *maae in the same time*, as besides increasing the number of pieces he has decreased his shop expense per piece, making a larger output for the capital invested.

When these facts are considered it is little wonder that many mechanics fail to see any good in the piece-work system, as it too often means harder work for the men and very little higher wages, after a few months, for viewed in this light it is merely a plan to make a larger output for a day's work. The advantage of the system, *for the men*, seems to depend on whether the manager is willing to divide the saving it produces with *those who do the saving*, or whether after finding how much a man can do (when he has an object in working extra hard) he practically makes this a basis on which to pay about the old day rate. The piece-work principle is correct, and when applied by a man who is thoroughly just to his firm, his men and himself, is a good thing.

FOR THE NOTE BOOK.

IN THIS COLUMN WE PUBLISH PRACTICAL RULES AND DATA THAT WILL BE FOUND USEFUL TO SHOPMEN GENERALLY; AND WE SHALL BE PLEASED TO CREDIT ANY CONTRIBUTION THERETO.

QUESTIONS CONCERNING ANY OF THESE NOTES WILL RECEIVE CAREFUL ATTENTION.

TO COMPUTE THE WEIGHT OF PIPES PER FOOT.

Subtract the square of the internal diameter from the square of the external diameter, both in inches, and multiply—

For cast iron pipe, by 2.45. For brass tubes, by 2.82.
For wrought iron pipe, by 2.64. For copper tubes, by 3.03.
For lead pipe, by 3.86.

SOLDERS FOR GLASS.

Mr. Chas. Margot finds that an alloy compos of 95 parts of tin and 5 of zinc melts at 200 degrees, and becomes firmly adherent to glass, and, moreover, is unalterable, and possesses a beautiful metallic lustre; and, further, that an alloy composed of 90 parts of tin and 10 of aluminium melts at 390 degrees, became strongly soldered to glass, and is possessed of a very stable brilliancy. With these two alloys it is possible to solder glass as easily as it is to solder two pieces of metal. It is possible to operate in two different manners. The two pieces of glass to be soldered can either be heated in a furnace and their surface be rubbed with a rod of the solder, when the alloy as it flows can be evenly distributed with a tampon of paper or strip of aluminum, or an ordinary soldering iron can be used for melting the solder. In either case it only remains to unite the two pieces of glass and press them strongly against each other, and allow them to cool slowly.—*Elec. Review, London.*

An alloy consisting of aluminum with 8 per cent. of copper and 12 per cent. of zinc is being used in this country for bicycles. The castings are said to be very rigid. Another alloy, consisting of aluminum with 3 per cent. of German silver, also gives good results. As cast, its specific gravity is 2.73, and its tensile strength is 10 tons per square inch. By rolling, the former is brought up to 2.83, and the latter to $18\frac{3}{4}$ tons per square inch. This alloy is whiter than pure aluminum.

AREAS OF CIRCLES.

In working out problems involving areas of circles it is often required to divide 0.7854 by some whole number. The following list of divisors leaving no remainder may be useful for the note-book:

0.7854 divided by	2	= 0.3927
	3	= 0.2618
	6	= 0.1309
	7	= 0.1122
	11	= 0.0714
	14	= 0.0561
	17	= 0.0462
	21	= 0.0374
	22	= 0.0357
	33	= 0.0238
	34	= 0.0231
	42	= 0.0187
	51	= 0.0154
33 × 2 =	66	= 0.0119
	77	= 0.0102
77 × 2 =	154	= 0.0051
	231	= 0.0034
231 × 2 =	462	= 0.0017

* * *

The *Pittsburg Dispatch* of September 11, 1895, publishes the following:

"E. E. Keller, of the Westinghouse Machine Company, has just returned from Europe, where he succeeded in obtaining for his company all American rights in a very important foreign invention. This is the Parson's steam turbine. It is just what its name implies, a turbine or rotating wheel, like a water-power wheel, only that it is driven by steam instead of by water. The steam is transmitted direct from the boiler against the turbine, striking it with great force. The turbine rotates and is connected by shafting with the electric generator, which is to furnish the power desired. It is claimed for this kind of turbine that each 15 pounds of water in the boiler will generate one electric horse-power, which is a very remarkable efficiency."

* * *

Gages for screw threads may be made of saw-blades, and have one side given a pitch to suit the pitch of the screw. The edges should be hardened.

WHAT MECHANICS THINK.

THIS COLUMN IS OPEN FOR THE EXPRESSION OF PRACTICAL IDEAS OF INTEREST, TECHNICAL OR OTHERWISE. WRITE ON ONE SIDE OF THE PAPER ONLY, AND BOIL IT DOWN.

WHEN SKETCHES ARE NECESSARY TO ILLUSTRATE THE IDEA, SEND THEM ALONG—NO MATTER HOW ROUGH THEY MAY BE, WE WILL SEE THAT THEY ARE PROPERLY REPRODUCED.

EXCHANGING IDEAS.

Would it not be a good plan for the readers of MACHINERY to send for publication a few questions with the view of bringing out different ideas on practical shop subjects—not on perpetual motion madness and the like. To begin with, let me ask for ideas and sketches for a milling cutter, about 9 inches in diameter, for milling steel structural material.

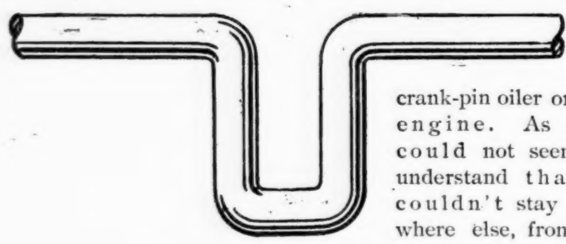
2. Best speed and feed for this work.

3. What is the best small boring bar that can be cheaply made by any toolmaker or machinist. FRANK HUDSON.

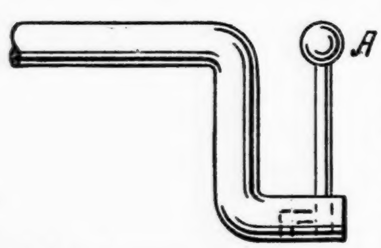
Tombstone, Ariz.

THE CENTRIFUGAL OILER.

Several of our apprentices, and men too, have asked me "What keeps the ball in the center," in referring to a centrifugal



crank-pin oiler on our engine. As they could not seem to understand that it couldn't stay anywhere else, from all the eloquence of my description, an object lesson seemed the best way out of it. So taking a piece of ¼-inch wire I bent it to the form of a crank-shaft as shown in the upper view, and of course any one could see that the outer end (right, in



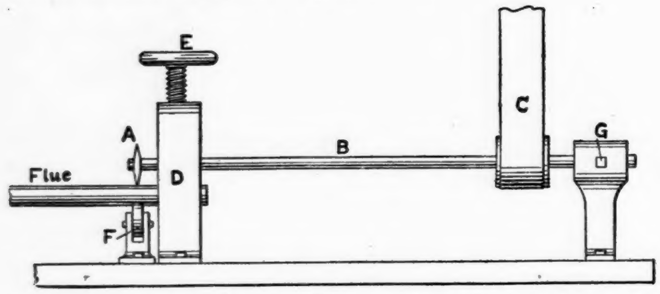
this case) would remain central when the piece was revolved by the left end. Then cutting off the right-hand portion I drilled a hole in the crank-pin portion and inserted the wire with the ball *A* representing the ball on the oiler. Then revolving by the left portion once more, it was easy to see how and why the ball remained in position. The oil-way shown explains itself.

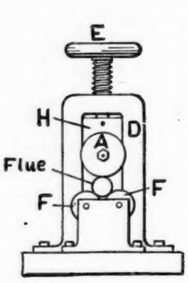
CENTRIF.

A FLUE CUTTER.

In locomotive repair shops boiler work is an important item, and anything that tends to cheapen and facilitate it will be regarded with interest.

In the Fallbrook shops this flue cutter is used instead of a pipe machine. It is a cheap rig, costing less than $50.00, and a boy can cut off ends as fast as two per minute.





The wheel cutter A is mounted on the shaft B, and is driven by belt C. It is raised and lowered to cut the flue by the hand-wheel, which moves the sliding block H. The belt end of shaft is pivoted at G to move freely.

The flue rests on two pairs of friction rollers, and during the cutting off rotates rapidly, the cutter running about 100 revolutions per minute. F. E. ROGERS.

Corning N. Y.

BELL CHUCKS.

The Direct Separator Co. has occasion to use two bell chucks on the lathe for every different size of separator. To avoid the cost of threading these numerous chucks on the lathe-spindle, the plan shown in Fig. 1 has been adopted. The chucks are simply bored and faced to fit the nuts and shoulder of the lathe-spindle and one nut does for all chucks.

To remove chucks from the lathe spindle, if put on in the ordinary way, is troublesome; but with the nut shown, it is only necessary to drive the ring B off the conical surface of the nut A, which is split open; then the whole can be run off by hand. In the work referred to, where a piece has been threaded at one end

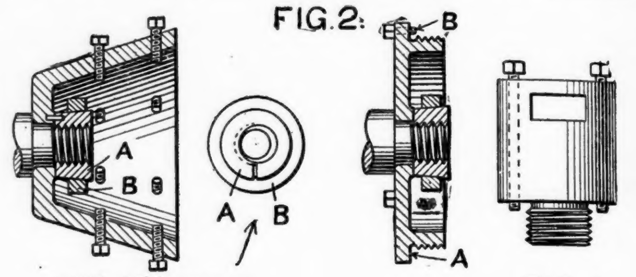


FIG. 2. FIG. 1. FIG. 3. FIG. 4.

and as it is held in the chuck (see Fig. 1), it is screwed on to piece (Fig. 2) to thread the other end. If the piece were allowed to screw up tight against the shoulder as at A, it would be forced up so tight as to come off hard. To avoid this, two or more set-screws, as at B, are screwed up tight against their heads, and the points faced off true. The piece to be threaded is allowed to screw up tight against the points of these screws, and after the work is finished, slacking back the set-screws allows the work to be readily removed.

Fig. 4 shows the application of the same principle to a plug for screwing on screwed heads. R. G.

CUTTING SPEEDS.

A great deal is being said about the cutting speed of machine tools. Brown thinks that because Smith is running his machines fast, that he (Brown) can do it too. Now in this he may be mistaken. Smith has good machines, uses a good grade of iron and uses Mushet steel tools. Brown uses ordinary steel and his iron is harder than the hinges of Hoboken; yet from the fact that he is turning or planing *cast iron* he is going to run his machines as fast as Smith does. And he is going to get left. I get a cylindrical casting to turn up, from which I cut off cylinder packing rings ¾×¾. In turning, run the lathe on slow speed with $\frac{1}{16}$ feed by $\frac{3}{16}$ depth of cut. In cutting off I use a $\frac{3}{16}$ Mushet steel parting tool, and cut off the twelve rings with one grinding of the tool, and running the lathe one speed faster than in turning. I get another casting exactly like the first, and for the same purpose, but it is the "Brown" kind of iron. I lose time on it, yet it is *cast iron* in both cases.

In regard to the use of water, I have wrought iron jobs that no water is used on, except on a light finishing cut. Yes, the work gets hot and I take it out and cool it off. It will be noticed in turning wrought iron, the cutting-edge of the tool will get foul by an accumulation of particles of iron which protects the edge, yet continues to cut; while with the use of water the tool is kept clean, and gets dull a great deal quicker than in the dry case. After all, I am inclined to the belief that piece-work is the best solution of this cutting speed question.

Indianapolis, Ind. W. DE SANNO.

THE TRANSMISSION OF POWER BY ROPES.

The article with above caption, by Mr. John H. Cooper, in your issue for October has been received with much interest here, where the American system had its birth. It originated with the Dodge Manufacturing Company, and to the persistent efforts of that company the country owes whatever benefits have or may come from so radical a departure. Much has been written upon rope transmission within the past few years, since the American system has been recognized, but mostly by persons who have not gone very deeply into the practice of the American system. The engineering literature on this subject is mostly based on observations of the English system, which is a horse of quite another color. Hence, there has been much speculation and many learned reflections upon the proper angle of the grooves, and one gentle-

man has gone to the extent of patenting adversity of angles for drivers and driven pulleys designed to equalize the grip, but unfortunately it seems a hopeless attempt to formulate a rule which shall meet all possible relationships between driver and driven.

As a matter of fact, the most extended experience extant has evolved the fact that many conditions enter into the problem of endless rope transmission other than the angle of the groove, and in obedience to these conditions Dodge Manufacturing Company have abandoned the angle and make their grooves all round bottomed unless otherwise ordered. R. D. SMITH.

MORE TALL CHIMNEYS.

I noticed that in the September number of MACHINERY W. Barnett Le Van has a list of the tallest chimneys in the world, and I also notice that he has omitted two very tall chimneys in Providence. The chimney of the Union Railroad Power House being 210 feet high, and that of the Narragansett Electric Lighting Co. being 250 feet. As a resident of Providence and a mechanical man I take considerable interest as well as local pride in these chimneys, especially as I have been on top of the tallest one, would call your attention to the omission.

Providence, R. I. J. P. WILLIAMS.

The chimney of Mattheson & Hegeler Acid Works, at La Salle, Ill., is 225 feet high and the Illinois Zinc Co., at Peru, Ill., has a chimney about 180 feet high. ALBERT H. HALLADAY.

Spring Valley, Ill.

The Russell & Irwin chimney is 177 feet high and the P. & F. Corbin, finished in August, 186 feet high. Both of New Britain.

MULTIPLYING VULGAR FRACTIONS.

Referring to Mr. Topham's article on page 25 of September issue, the advantage is not always with decimals. For instance:

$$3\tfrac{1}{6} \times 2\tfrac{1}{3} = \tfrac{19}{6} \times \tfrac{7}{3} = \tfrac{133}{18})133(7\tfrac{7}{18}$$
126

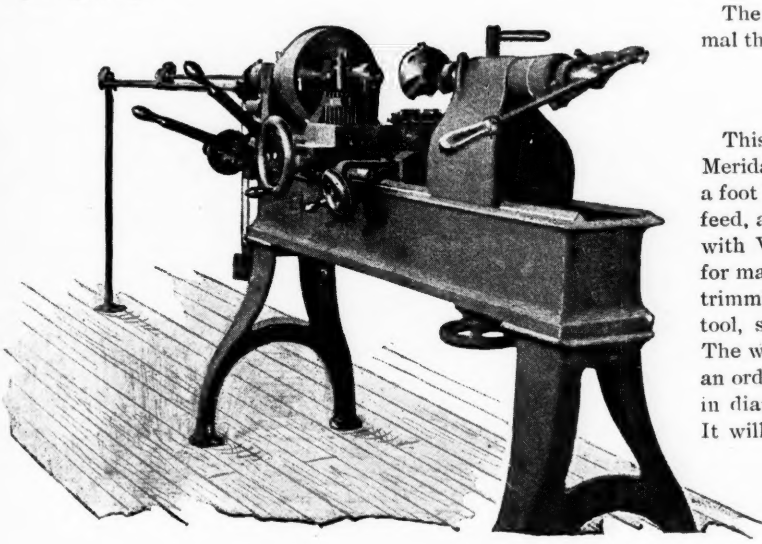
requiring 20 figures. By decimals to obtain equal accuracy would be impossible; but as sufficiently approximate accurracy may be had by using four "places" we get this:—

2.3333
3.1667

163331
139998
139998
23333
69999

7.38886111

requiring 47 figures.



Even with Mr. Topham's own illustration, by decimals:

3.40625
3.25

1703125
681250
1021875

11.0703125

we have 38 figures; but by vulgar fractions only 31.

$3\tfrac{13}{32}$
$3\tfrac{1}{4}$

$10\tfrac{7}{32}$ } 124
$\tfrac{24}{32}$ }
$\tfrac{13}{128}$

11 $\tfrac{9}{128}$

Or we may put it thus

$\tfrac{109}{32} \times \tfrac{13}{4} =$ 327
1090

1417 (128
128 ($11\tfrac{9}{128}$

137
128

and require only 37 figures, as against 47 by decimals.

Taking Mr. Topham's case of complex fractions :—

$$(\tfrac{2}{3} \times \tfrac{7}{8} \times \tfrac{1}{4}) \div (\tfrac{1}{4} \times \tfrac{5}{8} \times \tfrac{1}{8})$$

we have by decimals

.6667	.625
.875	.25
33335	.15625
46669	.125
53336	
.5833625	78125
.25	31250
	15625
29168125	.01953125
11667250	
.145840625	

.145840625 (.01953125
13671875 (7.4670 ×

9121875
7812500

13093750
117.8750

13750000
13671875

781250

calling for 182 figures; while by vulgar fractions with cancellation, thus:—

$$\frac{2}{3}\ \frac{7}{\cancel{8}}\ \frac{1}{\cancel{4}}\ \frac{\cancel{4}}{1}\ \frac{\cancel{8}}{5}\ \frac{8}{1} = \frac{112}{15})112(7\tfrac{7}{15}$$
105

it takes only 27.

The liability to error in this example is much greater by decimal than with vulgar fractions. FIGGURER.

* * *

SPECIAL COMBINATION MACHINE.

This is one form of the regular 20-inch forming lathe of the Meridan Machine Tool Co., Meriden, Conn., and is fitted with a foot block, tool post on front of forming slide, automatic wire feed, almond turret fitted to foot block spindle and is equipped with Vanderbeck's self-oiling counter-shaft. It is designed for manufacturers of lamps, brass bedsteads, tables, clock case trimmings and similar work, and will finish with the forming tool, spelter or brass castings up to 5½ inches in diameter. The whole tool slide can be manipulated exactly the same as an ordinary slide rest, spelter or brass castings up to 18 inches in diameter can be finished by slide rest and hand turning. It will make from rods screws, nipples, arrows, knobs, etc., up to 1-inch in diameter. It will do as large a variety of work as is required by manufacturers of the goods, and is one of the most modern of tools for economical production.

* * *

WHAT is claimed to be a new alloy, which is a very good substitute for gold in many ways, consists of 94 parts copper to 6 parts antimony. The copper is melted and the antimony then added. After perfect fusion has occurred, a little magnesium and carbonate of lime is added to increase its density. The alloy can be drawn out, worked and soldered similar to gold, which it very closely resembles when polished, and it preserves its color, even when exposed to the action of ammoniacal salts or nitrous vapors. The cost of the alloy is about 25 cents a pound avoirdupois.—*Information.*

THREE LIMITED TRAINS TO ATLANTA, GA., VIA. SOUTHERN RAILWAY.

To accommodate the heavy travel to Atlanta, Ga., on account of the Cotton States and International Exposition, commencing Sunday, October 6, in addition to the two limited trains now in operation between New York and Atlanta via. the Pennsylvania R. R. and Southern Railway "Piedmont Air Line," a third train will be put on which will be known as the Exposition Flyer, leaving New York daily at 11 o'clock A. M., reaching Atlanta the following morning at 10 o'clock. This train will be composed of Pullman drawing-rooms, sleeping and vestibule coaches. The equipment of the new train will be excellent in every respect; the hour of departure and arrival at Atlanta are most convenient. This will, no doubt, as soon as known to the traveling public, be as popular as the famous Washington and Southwestern Vestibule Limited operated by this system between New York and Atlanta, which will continue to leave New York as heretofore, daily at 4.30 P. M.

MANUFACTURING NOTES.

An interesting fact to contractors is revealed by the use of the various systems of handling rock on the Chicago Main Drainage Canal. A day's work for a man in filling lime stone into shallow skips, as used on the Lidgerwood Cableway, averages between 16 and 17 cubic yards of rock in place for each ten hours' work, while the work of filling the cars, which are about 3 feet high, averages only about 9 cubic yards per man. This is a remarkable saving, and alone would justify the use of the cableway in hundreds of localities. It may be mentioned in this connection that there are now twenty Lidgerwood Cableways, which are manufactured solely by the Lidgerwood Manufacturing Company, New York, in use in the construction of the Chicago Main Drainage Canal.

The Diamond Machine Co., of Providence, R. I., have lately received a large order for their Patent Lever and Screw Feed Lathe to go to a Manual Training School in California. They supplied Leland Stanford University with about 25 of these lathes some two years ago. This company is getting out several orders for their large Surface Grinding Machine and also for their Automatic Knife Grinder.

The Brownell Co., of Dayton, Ohio, are building an addition to their plant, so as to be able to take care of the increasing demand for their boilers and engines. They have closed a deal with the Lodge & Davis Machine Tool Co., of Cincinnati, Ohio, for the necessary machinery to equip the new addition.

The Lane & Bodley Co., of Cincinnati, report a very fair recent business with Mexico. A steam plant for a Government school, a saw mill, an engine for sugar mill, an engine and boiler for electric lighting a race course, a complete Corliss engine steam plant with transmission machinery for a woolen mill being received within a few weeks.

FRESH FROM THE PRESS.

Compressed Air. Frank Richards, M. E. Over 200 pages. Illustrated. $1.50. John Wiley & Sons, New York. This is a timely book on a subject which is attracting much attention and which is unfortunately too little understood. Written by a man who has had wide experience in air compression and its use, as well as in general mechanical lines, his writings appeal strongly to the mechanic, and no shop manager or superintendent can afford to be without this, to aid in understanding the use and abuse of compressed air. The data and tables, as well as the practical examples given, will be of use to the designer as well as the careful user of air compressors, and should do much to further its use in many places. The author deserves the thanks of air compressor builders as well as users, and those who will probably become users when they understand the question more thoroughly. It is a book that can be heartily recommended to all interested in the subject, and this should include all who are striving for shop economies, as the question of handling comparatively light material is an important one for which compressed air seems peculiarly adapted.

A Library of Steam Engineering. John Fehrenbatch, M. E. 8vo. pages. Illustrated. The Ohio Valley Company, Race street, Cincinnati, Ohio. $5.00. A fine specimen of the printers' and binders' art, it contains a frontispiece, a half tone portrait of the author and is finely illustrated throughout. It is a very comprehensive treatise, comprising about all the phases of steam engineering that are likely to be needed by the engineer or mechanic. Safety valve calculations are exhaustively and clearly treated, and boilers and boiler settings are also given considerable space, which is well worthy of careful perusal. The indicator also receives attention. All calculations are clearly explained, which is a commendable feature, as it allows the student to follow each step intelligently. Some of the leading types of engines are shown, and among them an ingenious but rather complicated type known as the Weir-Harden, which it seems to us receives undue prominence in a book of this character. This is still more noticeable when, under the head of Compound Locomotives, the Weir-Harden is the only one mentioned. Those unacquainted with railway practice might readily think this the only kind in existence, when in reality there are thousands of various types in regular service, while the one shown, unless we are very much mistaken, exists only on paper at this writing. It is to be regretted that a book which contains so much valuable information should be used to push an impractical device, although this does not, of course, detract from the value of the other portions. The book is sure to interest and instruct its readers and will be a valuable addition to any library.

Modern Examinations of Steam Engineers, or Practical Theory Explained and Illustrated. W. H. Wakeman. 12mo. cloth. 280 pages. 53 chapters. The American Industrial Publishing Co. $2.00. The author is well-known to our readers as a practical steam engineer, and has contributed many articles to the mechanical press. His book was written for the working engineers of to day, and we consider it a complete work. It contains many rules and formulas concerning engines, boilers, steam heating, the indicator, strength of shafting, power of belts, designing chimneys, heating feed water, safety valves, condensers, etc., which are fully explained and examples worked out by them in order that the reader may easily understand what is meant. It will prove valuable to the engineers and firemen who wish to pass a creditable examination for government or state license, to steam users who wish to understand their plants, and to all who desire to improve and add to their knowledge of steam engineering. It contains 300 examination questions, which are entirely separate from the 53 chapters of reading matter, and are indexed in order to enable the reader to readily find the answers in the text. There is also a general index of subjects treated of which adds to the value of the work. Orders for the book may be sent to the author at New Haven, Ct., or to the publishers at Bridgeport, Ct.

Rapid Lathe Work. Fifth Edition, 1895-96. Jones & Lamson Machine Co., Springfield, Vt. This is the latest catalog of this enterprising concern, and compares very favorably with their previous artistic productions in this line. It is devoted to the merits of the Hartness Flat Turret Lathe, a machine which is too little known, although their numbers are rapidly increasing. The illustration of "a leak at the bung" is well worth careful study as well as the information the book contains on shop management. Samples of work are shown, part in half-tones, which are particularly fine, and the time taken for some of the work is also given as an illustration of the economy of the machine. The working parts of the lathe are shown, some of its details, such as tools and cutters, and some of these are particularly ingenious. There is another departure from regular practice shown, which consists of what might be called false turrets, each containing tools for one particular job and used only for this, saving time of setting tools. We shall give some details of this later, in an article on Turret Machinery.

The Correspondence School of Technology, Cleveland, Ohio, send us their catalog for 1895-96 which contains information concerning the studies taught, the methods employed and also the list of instructors, whose prominence assure thorough and conscientious work. They also offer technical books to students at a liberal discount, and to those who complete a course this continues during life. The courses are very thorough, including electrical engineering, steam engineering, bridges, roof and iron structures, surveying and roads, mechanical engineering and hydraulic engineering, varying in price from $35 to $50 for advance payments and from $40 to $60 for installments. Those interested should send for catalog and they will be repaid.

The Prentiss Vise Co., of 47 Barclay street, New York City, have issued a new catalog of their well-known vises which contains several new styles that will be appreciated. They are now making a solid jaw jeweller's vise, with anvil, having either a swivel or stationary bottom as desired. Their Rapid Transit vises are very simple and not liable to get out of order. A new filer's vise made with a steel bar of channel section, having the screw protected by the bar, is made with either swivel or solid bottom and solid jaws—this makes a very strong vise. A combination pipe vise is also shown and a new and novel form of pipe vise having an open side, which will commend it for a large variety of work.

The Frick Co., Engineers, Waynesboro, Pa., send a very neat 56 page catalog of their Automatic Engines, which is arranged in their well-known style, finely printed and illustrated with numerous half tones. Several views of the shops are shown and the details of the engines give a clear idea of their construction and merits; among which are Penney's Governor and Sweet's Balanced Valve. Compounding has received careful attention, and both tandem and cross compounds are shown as well as vertical engines of the latter type of cylinders. Useful tables are given concerning the engines and there is also a little talk on boilers. There is much information contained in this catalog which will interest engineers and mechanics.

A copy of the "Illustrated Catalogue," New York Central's books and etchings, will be sent free, postpaid, to any address in the world, on receipt of two 2-cent stamps, by George H. Daniels, General Passenger Agent, Grand Central Station, New York.

Messrs. Bryan & McKibbin, of 120 Broadway, N. Y., announce that they have been appointed General Eastern Agents for the Sligo Rolling Mills, the A. Leschen & Sons Wire Rope Co., the Oriel Lumber Co., the Buckeye M. I. & C. Co's., "Little Giant" Coupler.

BUSINESS.

NO CHARGE IS MADE FOR THE INSERTION OF BONA FIDE ITEMS UNDER THE ABOVE HEAD. FOR FURTHER PARTICULARS ADDRESS THIS OFFICE.

An energetic mechanic, running a small shop in North Carolina, could handle a line of engines, boilers and machinery to the advantage of all concerned.

The inventor of a practical caliper would like to find a manufacturer to make it and place it on the market.

A well-known English mechanical engineer desires to represent American manufacturers in London, England.

An experienced mechanic, thoroughly familiar with South America, can place American pumping and railway machinery to advantage.

The National Machinery Co., Tiffin, O., are likely to be in the market for one milling machine with 5-foot table and one with 6-foot table, the above machines to have all improved attachments to be pillar and knee style, and to weigh from 4,000 to 5,000 pounds; one gear cutter, full automatic, to cut from 50 to 60 inches diameter, 8 to 12 inch face; one universal grinding machine, to swing 12 inches and to take 30 to 40 inches between centers; one lathe, to swing 16 inches, with taper attachment; one engine lathe, to swing 20 to 22 inches.